CSCL 2013

Computer Supported Collaborative Learning

June 15–19, 2013

University of Wisconsin – Madison

To see the world *and* a grain of sand:
Learning across levels of space, time and scale

Conference Proceedings Volume II

Short papers, Panels, Posters, Demos & Community Events

Editors: Nikol Rummel, Manu Kapur, Mitchell Nathan, Sadhana Puntambekar

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To See the World and a Grain of Sand: Learning across Levels of Space, Time, and Scale. Proceedings of the International CSCL Conference 2013

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The 10th International Conference on Computer-Supported Collaborative Learning (CSCL) is to be held at the University of Wisconsin-Madison, USA, from June 15 through 19, 2013 (http://www.isls.org/cscl2013/).

The CSCL conference is a multidisciplinary, international meeting sponsored by the International Society for the Learning Sciences (ISLS). The conference is held biennially in the years alternating with the International Conference of the Learning Sciences (ICLS). So far the conference has been held in the USA, Europe, and Asia. This conference is an important venue for CSCL researchers to come together from around the world to meet, report recent research findings and discuss timely and important issues of interest to the community. It draws researchers from psychology (educational, social, developmental, cognitive, linguistic, cultural-historical), the social sciences (anthropology, sociology, communication studies, philosophy of language), and design disciplines (computer and information science, curriculum and didactics), as well as researchers from Artificial Intelligence (AI) and the cognitive sciences.

CSCL interactions in both online and face-to-face contexts occur at multiple levels of time, space, scales of analysis, and scales of group/population structure, to name a few. The title of our conference theme, inspired by (and modified from) William Blake's poem "Auguries of Innocence" reflects this unique aspect of CSCL in which interactions and learning need to be understood, supported and analyzed at multiple levels. We see an attention to the theoretical, methodological and technological issues of addressing research at multiple levels to be one that is highly responsive to current research among the CSCL community as well as developing emerging epistemological and methodological issues that will shape our intellectual efforts well into the future.

The relevance and timeliness of the conference theme is evidenced by workshops and presentations at previous ISLS conferences and by recent publications in relevant journals. For instance, the issue of *analyzing* CSCL interactions at multiple levels and with various methodological approaches, in order to further our understanding of the learning mechanism underlying CSCL, has received a lot of attention in the community over the last decade. At ICLS 2004 Nikol Rummel and Hans Spada organized a symposium entitled "Cracking the Nut – But Which Nutcracker to Use? Diversity in Approaches to Analyzing Collaborative Processes in Technology-Supported Settings." At ICLS 2008, Daniel D. Suthers, Nancy Law, Carolyn P. Rose, Nathan Dwyer held a workshop with the title "Developing a Common Conceptual and Representational Framework for CSCL Interaction Analysis", which was followed by a series of workshops at the recent CSCL and ICLS conferences and culminated in an edited book to appear in June 2013 at Springer: Suthers, D., Lund, K., Rose, C. P., Teplovs, C., & Law, N. (in press). Productive Multivocality in the Analysis of Group Interactions. Furthermore, in his introduction to the most recent issue of the International Journal of Computer-Supported Collaborative Learning (ijCSCL, Volume 8, Issue 1), which is dedicated to the topic of "Learning across levels", editor-in-chief Gerry Stahl cites and takes up the CSCL 2013 conference theme to argue that "time has come for CSCL to address the problem of traversing levels of analysis with exacting research" (p. 10).

At CSCL 2013, the conference theme is addressed from different perspectives through three keynote talks by Josep Call (Max Planck Institute for Evolutionary Anthroplogy, Leizpig, Germany), Kori Inkpenn Quinn (Microsoft Research, USA), and Justine Cassell (Carnegie Mellon University, Pittsburgh, USA). The conference theme will further be showcased by an invited plenary session on "Multiple methods in CSCL research", and by various pre-conference workshops and multiple contributions (paper and poster sessions, submitted and invited symposia, panels, and demonstrations of innovative educational technology) throughout the main conference.

We received many high-quality submissions for CSCL 2013. Submissions categories included full papers (8 pages, presenting mature work), short papers (4 pages, summarizing work that is still in progress or of smaller scale) and posters (2 pages, sketching work in early stages or novel and promising ideas). Further submission categories were symposia (8 pages, conveying larger ideas or integrating findings around a specific issue), panels (3 pages, coordinating multiple perspectives on a specific, timely topic), demonstrations (3 pages, providing an opportunity to interactively present new tools and technologies for supporting and/or analyzing collaborative learning), and pre-conference workshops and tutorials (5 pages, proposing collaborative knowledge-building sessions where participants actively work together on a focused issue). Submissions were also invited for a doctoral consortium and an early career workshop.

Each full paper, short paper, or poster proposal was reviewed blind by one or two peer reviewers and one program committee member. Program committee members then summarized the reviews and provided the program co-chairs with a brief assessment. Finally, the program chairs carefully considered the reviews and the meta-review, and in many cases read the submissions themselves before making the final decision. Proposals for symposia and panels were reviewed by two program committee members and by the program co-chairs. Demonstration, workshop and tutorial proposals were reviewed by members of the respective steering committee within the CSCL 2013 organization.

As in previous years, the acceptance rates for full and short papers were competitive: The acceptance rates for full papers and short papers were 36% and 39% respectively. For posters, the acceptance rate was more inclusive (78%) to allow for presentation of work that is in early stages and for productive discussions of novel and promising ideas.

The CSCL 2013 proceedings comprise two volumes: Volume 1 includes full papers and symposia. Volume 2 includes short papers, posters, and panels, demonstrations, as well as abstracts for all community events (keynotes, workshops and tutorials, early career and doctoral workshops, and invited panels and symposia).

Many fields within the physical and social sciences and the design sciences have long grappled with the notion of *supervenience* -- how phenomena at one scale of time or space can influence and be influenced by those at larger and smaller scales. New technologies and methodologies are making theoretical advancements possible, and leading the exciting and growing field of CSCL into frontiers of research and development that stand to contribute to improvements in education, the design of new means for collaborating, and new end-user experiences. Our world is becoming a more connected place because of the ways -- both large and small -- that we interact with technologies, and in so doing, come to interact with one another. As organizers of this conference and editors of this volume, we hope these interactions continue well beyond the bounds of this event or these proceedings, but continue to reshape ourselves and the world.

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Short Papers

Visualizing Live Collaboration in the Classroom with AMOEBA

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Abstract: Collaboration in computer science class is vital for supporting novices, but few tools support substantive collaboration during in-class programming. In this work, we describe the implementation of AMOEBA – a new system that helps computer science instructors support student collaboration through live visualization of similarities in students' programs. We explore a single, 40-minute session of students learning to program for the first time. In that session, the teacher used AMOEBA to pair up students with similar programs to work together successfully; paired students' programs both became more similar to their partner and, on average, scored more goals. We then discuss implications and future directions for AMOEBA, including ways that it could be adapted to better support collaboration.

Introduction

Live classroom collaboration on creative computer programming projects is hard to represent. There are currently no widespread commercial tools available that provide real time analyses and visualization of student collaboration to support teachers' facilitation of students learning to program. In this work, we describe the design and implementation of AMOEBA – a new system that helps computer science instructors support their students in collaborating to write code. In this paper, we explore how a teacher supported collaboration with AMOEBA in a single, 40-minute session with novice students learning to program.

The design hypothesis of AMOEBA is that by visualizing uncommon similarities between individual students' program code as they produce it, the teacher or facilitator can match students who might be able to help each other progress. This hypothesis is controversial, as the vast majority of research into program code similarity deals instead with preventing cheating (e.g., Lancaster & Culwin, 2004). Such work fails to account for significant research in learning sciences and computer science education that has repeatedly confirmed that working in concert with other students of similar ability level can accelerate learning and make understanding more robust (e.g., Nagappan et al., 2003). This paper is intended to serve as a proof-of-concept that such collaboration visualization systems can add value to a computer science class.

Collaboration in the Computer Science Classroom

In computer science (CS) education, there has been an increased call for promoting collaboration in the CS classroom (e.g., Teague & Roe, 2008), especially for underrepresented students (Hug, Thiry, & Tedford, 2011). Analyses of how this collaboration is realized and its benefits have been frequently documented (Preston, 2005). However, among the software tools available to CS educators, there are a preponderance of tools to catch plagiarists (see Lancaster & Culwin, 2004) and few (if any) to determine if students are collaborating, though the evidence needed might be quite similar. Researchers have identified varying benefits of CS collaboration arising from social, cognitive, and affective factors (e.g., Teague & Roe, 2008). Collaborative programming approaches (such as pair programming) have been shown to contribute to novice student success, improved program quality, improved problem solving performance, greater productivity, and improved CS matriculation and persistence (Nagappan et al., 2003). Furthermore, though the benefits of collaborative programming have been frequently documented, operationalization of collaborative programming tends to focus on more general aspects such as assessment and grouping strategies (Preston, 2005).

AMOEBA

In order to better leverage the benefits of collaboration in computer science classrooms, we developed AMOEBA. Though AMOEBA was initially designed for post hoc analyses of collaboration (Berland, Martin, Benton, & Petrick, 2012), we realized that AMOEBA could be an effective tool for teachers to use in real-time in their classrooms. AMOEBA works by showing the current status of students in the classroom, with a circle representing each student in the class on the screen (see Figure 1). The teacher can change the location of the circles so as to mimic the physical position of the students in the classroom. As students begin to write programs, an *edge* (connecting line) appears between any two students whose program code shares statistically uncommon elements (the *similarity* metric is described below). This indicates to the teacher that two students have a 'surprisingly unlikely' amount of similarity between their programs. The level of similarity that will create a line between two students can be changed dynamically by the teacher at any time by adjusting a slider ('connection-threshold' in Figure 1), and each edge is labeled with the most unlikely similar elements between the two students' programs. Furthermore, AMOEBA allows teachers to track their interactions with students.

When a teacher uses AMOEBA to inform an instructional decision (such as pairing two students with similar code), the teacher can click on the students' circles; these clicks record the students' usernames and the time of the interaction allowing the teacher to track which students were paired together at which times.

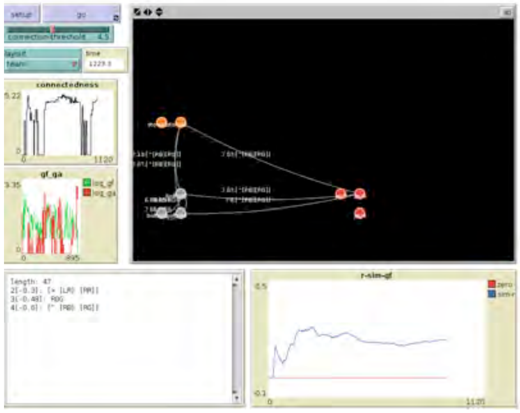

Figure 1. Screenshot of AMOEBA interface.

Methods

The participants in this study were 23 undergraduate students with no formal programming experience who were part of an educational technology course at a large public university. The study took place during a unit on mobile learning environments in which the students were testing and evaluating mobile learning applications.

Materials

IPRO is a mobile, social programming environment in which each student programs a virtual robot to play soccer with and against the other students. In this study, each student ran IPRO on an iPad. Within the IPRO environment, students are encouraged to gesture and physically mimic the actions of the agent they are programming, as this has been shown to benefit students' learning (Petrick, Berland, & Martin, 2011). Additionally, the mobile nature of the IPRO environment affords greater collaboration as two students working in separate areas of the room can physically move to share ideas, bringing their programs with them on their iPads. All activity by any student in IPRO is captured in the *log* – the primary source of data in this study.

Collaboration in an IPRO classroom builds upon students' "positive interdependence" (Preston, 2005), as each student works toward the visible goal of programming a robot to score (or block) goals both for herself and for her team. Moreover, the environment is intended to build upon special affordances of group interactions such as distributed cognition that may lead to higher quality programs (Petrick, Berland, & Martin, 2011). Building upon these and other best practices of CS collaboration, we sought to improve visualization and oversight of student interactions, which is a noted limitation of existing work (see Preston, 2005).

Procedures

This study was conducted during a 40-minute session as part of the students' normal class. Students were given a handout with a key to the IPRO 'primitives' (core elements). Then the classroom teacher, the second author of this paper, described the IPRO application and its use in computer science classes. A large screen displayed a series of simple IPRO programs, and the teacher led the students in physically enacting the movements of the robot, at which point each student logged into IPRO with a unique login ID. Students were assigned to one of 4 teams of 5-6 students each. The teacher demonstrated how to write basic IPRO code. Then the students were given time to work on their programs. Initially, most of the students worked individually.

While the class was programming, the teacher assisted with technical issues, but she did not provide any help writing code. During this time, the teacher also monitored AMOEBA. After approximately ten minutes of unsupervised coding time, the teacher asked pairs of students with high *similarity*, indicated by an AMOEBA *edge*, to work together. Each time the teacher directed two students to work with each other, she also marked it in AMOEBA by clicking on the circles representing those students. Of the 23 students in the class, the teacher directed 4 pairs of students to work together. The remaining 15 students were not asked to nor restricted from working together. At the end of the programming session, there were two matches in which the four different teams faced off against each other. The matches were projected on a large screen for the class to watch.

Measures

The *similarity* metric is based on Dunning's (1993) metric of *surprise* in computational linguistics. Given all sub-trees of the parse tree of two students' code, the *similarity* of two students is the calculated *surprise* of the maximally *surprising* isomorphic sub-tree of the two students normalized to the percent of the maximum observed *surprise*. The metric is similar to *tf-idf* (Salton, 1989), which is the number of terms in common times the inverse frequency of that term in the corpus as a whole. Conceptually, this similarity metric is meaningful because two programs with identical code are solving a problem similarly (by definition). Program code, even in a limited language like IPRO, can vary enormously. In C++, there are infinite variations of source code that could produce 'hello world'. That said, (almost) every one of those programs will have 'int main(...)' at the beginning – that code is common to almost every C++ program ever written. By using a similarity metric that matches isomorphic code but discounts code provided by teachers, required code, or obvious code (such as 'int main(…)' in C++), we can find students who are using similar logic and approaches. Figure 1 (above) shows edges between students where the similarity between two programs is unlikely to happen by chance; the threshold for likelihood is dynamic and can be changed by the teacher at any time with a slider.

Every time a student made any change to their program, the log registered a new *program state*. We evaluated changes to students' programs over time by analyzing differences in program states over time. *Program length* is determined for each program state by counting the number of primitives in the state of the program, which is similar to the number of lines of code in other programming languages.

We measured the *program quality* (PQ) of each program state of each student's program by running the state of the program in a simulator with various scenarios for approximately 10,000 turns per program state. The simulator then generates a number for "goals scored by the robot" (GF) and a number for "goals scored against the robot" (GA). PQ is calculated by subtracting GA from GF (PQ = GF - GA).

Results

In reporting results, we primarily compared paired students with non-paired students starting from the approximate time point when the pairing began. Additionally, we compared the level of similarity of program states of paired-students to their respective partners before and after the students were paired. Figure 2 shows average values of GA, GF, length, and similarity for both non-paired (left) and paired (right) students over time.

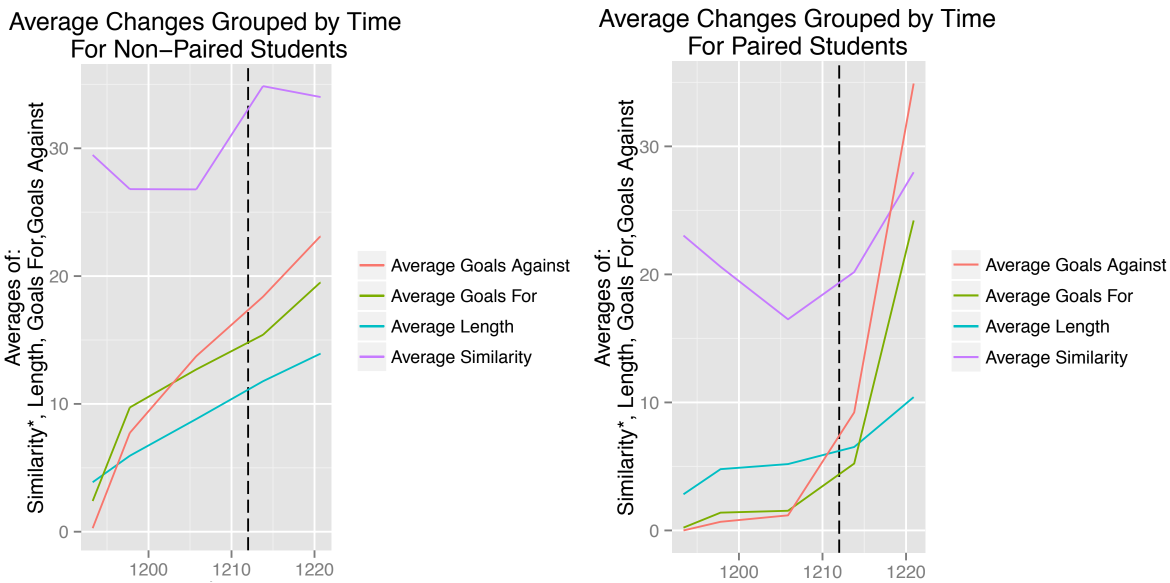

Figure 2. Average change of program descriptors over time for non-paired (left) and paired (right) students. The dotted vertical line marks the time at which the teacher paired students.

Similarity. The mean similarity scores for paired students to their partner before being paired was 19% and after being paired, it rose to 27%. The mean similarity score of all scores for non-paired students to one another before pairing time was 27%. These mean scores increased for both paired and non-paired students (as per Table 1). A closer examination of similarity in relation to time indicates a moderate to strong correlation of similarity to partner for paired students (r=0.42); whereas there is no significant correlation of time to overall similarity to one another (r=-0.16) for non-paired students. In other words, after two students were paired together, their programs tended to become more similar.

Length. Non-paired students tended to write longer programs than paired students (See Table 1). Among paired students, there was a large significant correlation between time and program length (r=0.43) and a large correlation among non-paired students as well (r=0.70). Thus, program length tended to increase over time for both paired and non-paired students.

Program Quality, Goals For and Goals Against. The paired students had lower average program quality than the non-paired students (Table 1). The paired students had a higher average GF and a higher average GA; that means that the programs that they were writing both scored goals more frequently and were scored against more frequently – better offense, worse defense. Both paired and non-paired students exhibited similar trends among PQ, GF, and GA. The PQ for both groups was negatively correlated over time (r_{paired}=-0.21; $r_{nonpaired}$=-0.19), and both groups exhibited small correlations between time and GF (r_{paired}=0.26; $r_{nonpaired}$=0.21). Both paired and non-paired students' programs exhibited small correlations between GA and time (r_{paired}=0.25; $r_{nonpaired}$=0.22).

Table 1: Averages of Similarity, Length, Program Quality (PQ), Goals For (GF), and Goals Against (GA) across students' programs, based on whether they were paired or not.

	Similarity Before Pairing	Similarity After Pairing	Length	PQ	GF	GA
Paired Students	19%	26%	9.3	-18.06	38.05	56.11
Non-Paired Students	27%	34%	13.2	-4.96	26.77	31.47

Discussion

Overall, we found that the instructor had little difficulty using AMOEBA in the classroom, though she had not used it before. AMOEBA has very few "moving parts" – it does not require oversight. Quickly, and without training, the teacher was able to use the software to identify students with similar programs to match them together. Simply, our data suggest that the experiment was successful in prompting the teacher to encourage collaboration, and that collaboration was successful in helping students write better program code. The conclusion that paired students actually worked together is almost too obvious to state as a claim – it is a core assumption of innumerable classroom teachers. However, evidence exists that being conscious of how and when people are sharing can aid in collaboration (Hug et al., 2011), and, by providing a visualization and record, AMOEBA can prompt that reflection.

Limitations and Future Directions

We cannot make especially strong claims about the effects of collaboration or its impact on students' code; this study is not designed to be broadly generalizable. However, our findings, when combined with a wealth of history and theory about collaboration in computational learning, suggest that this work serves as a model for how we can support student collaboration *in situ* through simple, timely visualizations of data. That said, AMOEBA is too simple – it provides little information to the teacher about the quality of student programs. This lack of data may cause problems, as the teacher could pair two struggling students who are both struggling in the same way. The next version of AMOEBA will allow the teacher to visualize student similarity across a variety of metrics – structural similarity, program length, program quality, etc. In the interest of simplicity, however, we will keep buttons and choices to a minimum. Last, AMOEBA prompted questions of what similarities and differences best support peer programming and collaboration. Future work will investigate various teaching and pairing strategies, such as matching partners whose code varies widely in quality.

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AppleTree: An Assessment-Oriented Framework for Collaboration and Argumentation

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Abstract: In this paper, we articulate a framework (called AppleTree) for assessing collaborative argumentation with the purpose of evaluating and empowering the development of argumentation skills, collaboration skills and content knowledge in school learning. The framework is motivated by the need to achieve "learning to argue" and "arguing to learn" and the necessity to embed on-going and automated formative assessments for collaborative learning as reflected in existing literature. It builds on existing systems for collaborative argumentation and automated assessment of collaborative learning to achieve assessment for learning and to realize it in authentic classroom environments. We illustrate the framework by instantiating it in the conceptual design of one such system for use in schools.

Introduction

Understanding the significance of both "learning to argue" and "arguing to learn" (Scheuer, et al., 2010), Computer-Supported Collaborative Learning (CSCL) researchers have developed many computer-based systems to support argumentation in the collaborative fashion, to facilitate communication and argumentation between multiple participants (Scheuer, et al., 2010). A typical problem with the use of such systems is the low level of participation and interactivity in online learning environments. One way to foster productive collaboration is to empower regulation (i.e., supporting collaboration by taking actions "on the fly" to enable immediate adaptations when unexpected events occur during interaction, Dillenbourg & Tchounikine, 2007). Regulation is a complex skill depending on a quick appraisal of the current interaction situation and its compatibility with the desired (Jermann & Dillenbourg, 2008). This calls for embedding real-time assessments of collaborative learning in the system. Considering this, we conceptualized AppleTree, an assessment-oriented collaborative argumentation framework for measuring and fostering collaboration and argumentation in real classrooms. We hope AppleTree can make a difference to existing school practices via: 1) helping equipping students with 21st century skills (critical thinking and collaboration skills in particular); and 2) providing a workable approach to realize not only "assessment of learning", that is establishing what students have learnt in a summative way, but also "assessment for learning", that is using multiple forms of information about students' learning as feedback to modify the learning activities they are engaged in (Shepard, 2000). In the next few sections, we advocate the ingredients of assessment in such a framework, and propose a conceptual design of a system as an instantiation of the framework.

Ingredients of the AppleTree framework

In our assessment-oriented collaborative argumentation framework, we envisage automated assessment components that can assess both cognition development and social participation. The former is achieved through assessing the structure and validity of the represented arguments. The latter is realized through analyzing quantitative information concerning data-based usage of the system, including all the interactions involving argumentation and online-based communication. Knowledge on how participation in online environment contributes to learning is lacking (van Aalst, 2010). With the assessment components proposed, we seek to contribute to this topic by identifying good collaborative patterns that can bring about learning in domain knowledge, development in argumentation skills and improvement in communication and collaboration skills.

We propose the AppleTree framework that incorporates mechanisms for supporting formative (diagnostic) assessment of the on-going collaborative argumentation process in order to foster and enhance students' collaborative argumentation and optimize teachers' instruction. The key ingredients are:

1) It supports assessment *for* learning rather than assessment *of* learning.
2) It assesses *domain knowledge*, *argumentation skills* and *collaboration* at *individual*, *group* and *class* levels.
3) It is not only an assessment tool, but also a tool for visually representing learning processes unfolding or happening in classrooms.
4) It assesses not only the learning *outcomes* but also helps track and monitor the *process* of collaboration.
5) It involves both *self*-assessment and *peer* assessment by the students.
6) It is a *real-time* assessment tool which provides immediate feedback to teachers and students with which they can adjust or improvise teaching and/or learning, as well as 'feed forward' into future work.

In a CSCL system, if the ongoing analysis of the data is not available to teachers in real-time, it is usually too late for teachers to their adjust in-situ instruction and enactment strategies based on the assessment outcomes as the "end products". The visualization of on-going argumentation and collaboration amongst the students provides a version of a cockpit's view for the teacher to orchestrate classroom activities. AppleTree has the potential for providing teachers with the necessary information to tailor instruction to meet student needs. The feedback is intended to be less final and judgmental (Boud, 1995) but more interactive and forward-looking (Carless, 2002), timely and with a potential to be acted upon (Gibbs & Simpson, 2004), which can well facilitate teachers to enact collaborative argumentation activities to cultivate argumentation and collaboration awareness and skills in students.

Moreover, assessing students' performance in collaborative learning is not just the prerogative of the teachers. Equally, the students themselves need to understand own performances in a reflective way to help improve the productivity of their interactions. The AppleTree framework is intended to inform student learning: what learners are doing, what claims and evidences are they generating, editing, commenting or improving, what argumentative relationships they are establishing, where they are spending their time, how well they are progressing, and so on—at the individual or group level. It will inform students with regards to various aspects of argumentation and collaboration. The students have access to other groups' artifacts and assessment so that they can compare, critique and reflect. The integration of peer rating will encourage students to reflect on the learning process, to become more responsible and engaged in collaboration, so as to cultivate a collaborative culture in the long term.

An Instantiation of the Framework

To concretize the framework, we envisage a system that is conceived as a multiuser tool for developing scientific argumentation skills and collaboration skills in secondary school students (see Figure 1). Like most collaborative argumentation systems, its user interface provides students with a shared and synchronized working space for collaborative construction of arguments and a chat tool for communication and coordinating group work. A collaboration script (see following) is embedded in the system design to guide group members to do iterative cycles of intra- and inter-group interaction so as to achieve continuous knowledge improvement. Real-time visualizations and evaluations of students' social participation and argument construction at different learning stages are displayed to scaffold the argumentation processes and to inspire reflections on both individual and group work.

Argument Pattern and Representation

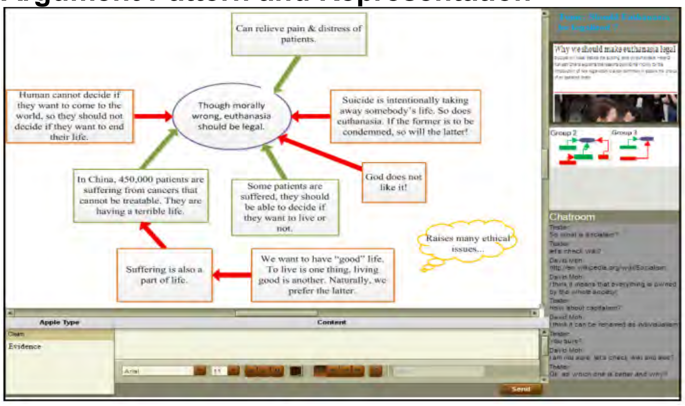


Figure 1. Screenshot of the AppleTree System

Table 1: Argument elements and examples

Argument Element	Textual representation	Graphic Representation	Example of an Argument
Claim	Claim		
Support	Evidence +For		
Rebuttal	Evidence +Against		
Placeholder			

For argumentation systems, providing an external representation to enable the creation, reviewing and modification of arguments by users is an important goal (Scheuer, Loll, & Pinkwart, 2010). An AppleTree implementation will use graphic representations, as graphic representation expresses the argument structure explicitly and is an intuitive form to model knowledge (Suthers & Hundhausen, 2001). There is the public working space in which an argument is an organized set of argument elements represented by nodes and/or directed links. The specific types of argument elements designed are in accordance with Toulmin's Argumentation Pattern (TAP) (1958), a most extensively adopted framework for both scaffolding and assessing argumentation in educational contexts (e.g. Jimenez, Rodrigues & Duschl, 2000; Mitchell, 1996). For both pragmatic considerations (e.g. understandability by the secondary school students) (Scheuer, et al., 2010) and assessment feasibility, three argument elements, namely claim, support (including data, warrant, or backing) and rebuttal are identified as the essential components of an ideal argument. On an AppleTree implementation, these three elements are indicated by: 1) the type of Node: Claim vs Evidence and/or 2) the type of directed Link: For vs Against (Table 1). Considering there are times students may come up with some idea but they cannot decide whether it is a claim, a support or a rebuttal, we provide a bubble node with an undirected link as "placeholders" where students can record these ideas. Providing these "placeholders" is important as it can encourage brainstorming and pooling of ideas.

Scripted Collaborative Argumentation

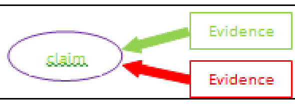
To realize constant improvement in argumentation via collaboration, an adaptive and generic script is integrated into AppleTree. Following this script, student collaborative argumentation process is composed of repeated two-staged (intra-group and inter-group) interaction episodes. At the first stage, students need to brainstorm, generate and further improve arguments within a group. When a group has agreed upon the argumentation graph created, group members are required to go to other groups' working spaces to evaluate the arguments developed. They judge whether the argument elements and links generated are valid or not by indicating whether they "Like" or "Dislike" it. Reasons for their judgment, which later can be used as constructive feedback with which the group being evaluated can use to further improve their arguments, are also to be provided. In the following episode, students go back to their own group to further improve the argumentation graph by addressing the feedback and adding the good points from other groups via further group discussion and negotiation. If time permits, a second round of inter-group evaluation can be enacted to seek greater improvement in group work.

Automated Assessment

Assessing Argumentation

AppleTree supports on-going automated analysis and evaluation of the argumentation graph. Argumentation quality is measured by "***structural completeness***" and "***content validity***" of the arguments constructed. A scheme for categorizing different levels of argument in terms of its structural completeness is embedded in AppleTree programming to enable automated analysis, visualization and comparison of collaborative argumentation graphs developed in different groups and/or at different phases of CSCL. At the conceptualization stage, based on the natural observations made of students' collaborative argumentation discourses occurred within small groups, 4 levels of arguments are identified in the coding scheme (see Table 2).

Table 2: Scheme for categorizing different levels of argumentation

Level	Description	Graphic representation (examples)
1	An argument that only contains a claim.	
2	An argument that contains a claim and support (s).	
3	An argument that contains a claim, support (s) and one rebuttal.	
4	An argument that contains a claim, support (s), and more than one rebuttal.	

Besides structural completeness, content validity is also an important facet for assessment as it not only reflects argumentation quality but also reveals students' understanding on domain knowledge. The realization of automated assessment of content validity is based on peer-rating during inter-group interaction. As described above, when having agreed on the group argumentation graph, group members shall go to other groups to evaluate the arguments developed. In peer-rating, each student will decide whether the elements proposed each is legitimate or not by selecting "Like" (valid) or "Dislike" (invalid). Thus argument content validity is indicated by the ratio between total number of "Like"s (N_L) and the total number of ratings received ("Like"s + "Dislike"s, $N_L + N_D$).

In addition to enabling automated assessment, peer-rating itself is also an important learning mechanism. Peer-rating engages students in making judgments about the performance of other students, a form of learning in which the contributions from others can be a very useful input for self-assessment. This provides an opportunity for learners themselves and their peers to understand and reflect what constitutes high-quality performance, and how the performances can be improved. It can be treated as a means for learning how to collaborate. From the aspect of domain knowledge learning, the disapproval of a certain element in the argumentation graph also unveils the conflicting understanding between students on this particular knowledge point. Through rating and commenting, individual understandings are pooled and aggregated. Students can explore these diversified thinking to form better understanding, leading to knowledge improvement. To facilitate this process, these "controversial" elements are highlighted via increasing the brightness of the graphic representation. The ratio between the number of "Dislikes" (N_D) and the sum of "Likes" and "Dislikes" ($N_L + N_D$) is calculated for each argument element and then translated into the brightness of the node and link representing that element.

Assessing Social Participation

On AppleTree, social participation is assessed by taking accounts of individual participation within the group and group participation within the class community. Students' participation rates of different functional interaction as well as the centrality of interaction are important indicators for their participation level. The data consists of AppleTree log files and students' inscriptional group artifacts on the shared argumentation space. Social network analysis (SNA), a well-known approach to investigate online social participation, is embedded in AppleTree to help identifying patterns of relationship between participants and visualizing the "flow" of information/knowledge and/or other resources that are exchanged among participations (de Laat, et. al., 2007). A variety of SNA indicators are used to examine the holistic interaction patterns and the positions of individual participant in it. In AppleTree, the analysis of the social network established focuses on "***centrality***" and "***density***".

Based on SNA, graphical representations visualizing the network connections developed can be generated in AppleTree. These can be used as immediate and intuitive feedback to help teachers and students to adapt their following activities in the classroom. It offers a method for mapping group interactions, visualizing 'connectedness' and quantifying some characteristics of these processes (de Laat, et al., 2007). However, this approach cannot reflect individual/group's contribution or participation ratio. Hence, in AppleTree, apart from using SNA to reflect relations (links) among participant/small groups, the distribution of different functional actions enacted by both individuals and groups indicated by action frequency is also incorporated. Quantitative information on students/groups' contributions in the shared argument space or interactional moves through online chatting are extracted and represented in AppleTree. Teachers or students can select the parameters what they are concerned about, for instance, the number of claims created; the number of evidences provided; the number of commented received.

Conclusion and Discussion

The need for an assessment framework for ongoing collaboration is motivated by the need to inform students with regards to various aspects of argumentation and collaboration and help teachers to manage and orchestrate collaboration activities in and after the classroom learning. We propose ingredients of an assessment-oriented framework for collaborative argumentation to provide views on the ongoing social participation and the cognitive progression of the argumentation structures and content. The tools are meant to help the teacher and students to have awareness of what is going on, as well as help the students to be more reflective on their participation and their contributions. Provided with these tools and resources for assessing collaboration skills, teachers can be more cognizant of what and how collaboration skills are to be assessed – thus enabling them to be better informed on how to support the development of these collaboration skills, an important component of 21st century skills.

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The Benefits of Single-Touch Screens in Intersubjective Meaning Making

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Abstract: What are the benefits of single-touch screens? The paper presents findings of one video extract from ten months of observation of single-touch screen interaction among 8-9 year-old children. Recent studies of collaborative learning mediated by digital touch screens and tabletops emphasize the possibilities for equal levels of verbal and physical participation. Additionally, these studies suggest that multi-touch technologies offer more task-oriented activities compared to single-touch screen interaction, in which discussion about turn-taking is more prevalent from the outset. In contrast, applying the Embodied Interaction Analysis, we find that the constraints of single-touch screens offer support for intersubjective meaning making in their capacity of constraining the interaction. This "grain of sand" shows how children display and construct a shared work space through embodied interaction with a single-touch screen.

Introduction

Within the CSCL community, researchers from a variety of disciplines seem to agree that new interactive multi-touch technologies might afford new possibilities for collaboration and participation among co-located peers (Dillenbourg & Evans, 2011; Mostmans, Vleugels, & Bannier, 2012; Rick, Marshall, & Yuill, 2011; Rogers & Lindley, 2004). Additionally, experimental and design related studies have highlighted these possibilities (see related work section) during the past 10 years. Nevertheless, Yuill & Rogers (2012) state that despite the many positive attributes of multi-touch technologies, these affordances might not support smooth collaborative learning. Likewise, pedagogical considerations on how to best implement these technologies in classrooms are still scarce, and most importantly, data from "natural" classroom settings in the form of video footage are few. With this in mind, we present our main research question for this paper; do single touch-screens offer support for children's intersubjective meaning-making in collaborative activities? Basically, we study how children negotiate and cultivate a "local rationality" (Heap, 1995), and in our analysis we focus on language, gestures and materials in the children's co-located activities with the single-touch screens. We want to know what benefits single-touch screens offer to children in their co-located collaborative learning.

Related Work

Three general approaches to research have been identified in CSCL: experimental and conditional studies, iterative design studies, and descriptive studies (Stahl, Koschmann, & Suthers, 2006). So far, research on collaborative learning mediated by interactive touch-screens and tabletops has been studied mostly from the first two research perspectives. The third category of research is not, on the other hand, widely represented within this area, and we argue that descriptive studies can produce important insights as to the contributions of (single) touch screens to intersubjective meaning-making. Consequently, this study intends to "explore and understand" rather than "code and count".

Experimental and conditional studies on interactive multi-touch tabletops suggested that this kind of technology can support collaboration, more equal forms of participation, and speedier conflict resolution (Hornecker, Marshall, Dalton, & Rogers, 2008; Rick et al., 2011). For example, Rick et al. (2011) presented work on three dyads working with DigiTile at the back of a classroom. Rick et al. subscribed to the common belief regarding the affordances of interactive tabletops, i.e. awareness of each other's actions and concurrent parallel work. Finally, Rick et al. suggested that enforcing equitable physical participation can disrupt the dynamics of collaborative activities. In another paper, Harris et al. (2009) reported a difference between multi- and single-touch technologies. His overall conclusion was that in the single-touch setting children talked more about turn taking, and in the multi-touch setting talk was more oriented towards the task at hand. In this experimental setting, the children were asked to make a seating plan for their classroom, and they were provided with information about the different pupil groups in order to make a successful seating plan. Likewise, Higgins et al. (2011) have compared the use of multi-touch tables with paper based tasks in a tabletop environment and suggested that the use of multi-touch tables is more conducive to the creation of a joint problem space in collaborative learning tasks. These results are based on numbers of touches and utterances.

From a design approach Yuill & Rogers (2012), Dillenbourg & Evans (2011) and Scott et al. (2003), to name but a few, have presented guidelines to support the integration of touch-technologies in learning settings. Scott et al. devised 8 system guidelines for co-located collaborative work on a tabletop. Among other things, they suggested that the technology should support natural interpersonal interaction, flexible user arrangement and simultaneous user interactions. Dealing with design and the implementation of touch screens for classroom teaching, Dillenbourg & Evans proposed 33 points for consideration when integrating touch tables into educational settings. The third design framework from Yuill & Rogers draws on social psychology theories of learning in their identification of three mechanisms that influence collaborative learning. These three are: *high awareness of others' actions and intentions, high control over the interface, and high availability of background information*. Additionally, Yuill & Rogers criticized the commonly perceived affordances of how the "natural" interaction with touch-technologies influences participation and collaboration in positive ways.

To repeat, the experimental approaches taken on interaction with various touch-interfaces attended to amount of talk, number of touches in an activity and the layout of the shared workspace in co-located peer-to-peer activities. The design related studies presented a mixture of abstract and concrete guidelines for the use of touch-technologies in collaborative activities. On the basis of our findings in these related papers, we suggest that a descriptive analysis of children's embodied interaction will shed light on the benefits of single-touch screens in meaning making in co-located learning projects. By means of a descriptive approach using video footage our aim is to uncover the methods that children use to accomplish learning (Stahl et al., 2006).

What Do You Mean by Meaning Making?

Intersubjective meaning making is our analytical focus in this paper. Intersubjective meaning making concerns the ways in which actors construct, display and maintain individual and shared perspectives of the task at hand. Matusov (1996) has outlined a series of questions regarding the study of intersubjectivity: what is involved in the process of intersubjectivity, what is the dynamics of it, and how is this process embedded in larger-scale practices and community life? These are core questions to work with if we want to understand intersubjective meaning making as a dialogue between peers, their gestures and use of materials. Several illustrations of this can be found in (Streeck, Goodwin, & LeBaron, 2011), where researchers present the way in which embodied intersubjective meaning making is unfolding across a variety of settings. Particularly, the way in which intersubjective meaning making is manifested and developed in the situation, and a certain local rationality (Heap, 1990) is formed. Likewise, Koschmann and LeBaron (2002) used different examples to illustrate that learner articulation is a verbal, gestural and material phenomenon. These three semiotic resources are intertwined and mixed in the process of intersubjective meaning making. In other words, these semiotic resources inform one another and "talk back" to each other. Analytically, the study of intersubjective meaning making is founded in traditions such as Conversation Analysis and Interaction Analysis. In our case, intersubjective meaning making is a combination of language, body, and materials in human-computer interaction. This concept is widely referred to as Embodied Interaction by Dourish (2004) and Streeck, Goodwin, and LeBaron (2011). As a consequence of this, our analysis of co-located children interacting with a single-touchscreen is focusing on the way in which the children are making sense in the activity through embodied actions. Particularly, the way in which a word, an artifact or a bodily gesture embodies the situated meaning making process. To sum up, we study how children are using various semiotic resources to make sense in front of single-touch screens.

A Peek into the Classroom Setting

Throughout one year, researchers collected a variety of qualitative data from two classrooms in a Danish school. We refer to Davidsen and Georgsen (2010) for a general introduction to the project. In this setting, single-touch screens were integrated to augment children's learning activities (1). The single-touch condition offers one item of input at a time, which is a constraint from a technological point of view. In total, 8 23-inch single-touch screens were distributed in two classrooms. Besides three teachers, 41 pupils (8-9-year old 2nd graders) participated. The pupils were working in pairs, using 23-inch single-touch screens with Internet access and with Smart Notebook software installed. In this setting, we collected more than 150 hours of video data from 7 different positions. Overall, this data consisted of three modes of interaction: verbal (e.g. children talking), gestural (e.g. children pointing at the screen, each other or the materials) and direct manipulation (e.g. children touching and moving objects on the screen). These modes of interaction are mediated by semiotic resources, and our focus is to study the interplay between the different semiotic resources. Moreover, we have studied the teachers framing of the children's collaborative activities in front of the screen. In Koschmann, Stahl, and Zemel's (2007) vocabulary, this learning setting is shaped by the children's embodied interactions and sense making processes and vice versa.

What Are the Benefits of Single-Touch Screens?

From the body of video data, we have chosen one extract of 22 seconds for this paper (2). This particular extract contains many of the typical findings from the data material. Moreover, the extract provides a good example of the benefits of single-touch screens to intersubjective meaning making in classrooms. As our analysis shows; meaning making takes place among semiotic resources. For example, the two pupils display, produce and maintain an intersubjective understanding of the activity through language, gestures and the single-touch screen.

This can be described as embodied collaborative actions. The situation we have selected is from the final part of the project, when the novelty of the touch screens has decreased. Awareness of collaborative actions, on the other hand, has been a part of the classroom activities for almost 10 months now.

Figure 1. Scene.


Figure 2. Iris (I) and Vince (V).

We follow Iris (left) and Vince (right). They are in the middle of producing a multimodal story about what happened on Good Friday. The kids wear headsets in order to listen to their production and make adjustments to their story. This video story is the final product of their work. Before they began their collaborative activity, all pupils in the class have talked about religious traditions, they have read about Good Friday in pairs of two, tested their knowledge in a multiple choice quiz and rewritten the story in their own words. Finally, they have to transfer their acquired knowledge into a video production, using the collaborative software on the single-touch screen. According to the teacher, the children themselves decided how to construct a meaningful story based on the previous activities during the week. This learning material was designed by the teacher as a six-staged script. The overall objective of this script was to teach the children about the Christian tradition of Easter, the training of language skills, and storytelling skills. For this paper, we focus on the final stage, namely the task of retelling the story in a video production by using the figures and the scene (see Figure 1). In this situation, the children are rehearsing their video production, reading aloud the text and moving around the objects on the screen. The children have written their account of the story about Good Friday in the booklet in Vince's right hand. The figures and scenery (Figure 1) they have to use to make the production were designed by the teacher. Before the activity started, the teacher showed the whole class how to use the collaborative software and the video screen recorder. However, the teacher did not give any instructions as to how to carry out the collaborative work in the pairs. Vince and Iris, the pair we are concentrating on in this paper, initially started to discuss who should read aloud the text and move around the figures accordingly. After a short discussion, they decided to divide the work between them, and agreed to swap after the first rehearsal in order for both of them to try moving around objects and reading the story aloud. Vince is reading the text in this episode. During the rehearsal, Vince was not able to follow what Iris was doing on the screen while he was reading their story from the booklet. Immediately after they finished their first rehearsal, Iris discovered that they were missing an object to cover Jesus. Hence, they agreed to make a rock. This means that they were in fact reconfiguring the original scene made by the teacher. What the children have noticed is that there is a discrepancy between the words of the story and the scenery designed by the teacher. It is a small difference that interrupted their activity. This breakdown in their rendering of the story influenced their reasoning about the material they are working with. The pair's reconfiguration was based on their knowledge from the story, and this became the object of their meaning making process. To sum up, this story showed that interaction with single-touch screens can be a highly social activity in terms of language, gesture and manipulation of objects on the screen. Additionally, our analysis showed that the children are taking over and repairing each other's actions on the screen.

The findings from our analysis suggest that single-touch screens impose a constraint that forces children into a process of collaboration and negotiation. At the beginning of this project, we saw the single-touch condition creating much frustration and individual work at the shared computer. In the situation analyzed in this paper, however, we see that the pupils have developed a practice of collaboration, which on the one hand allows them to push forward their own idea while still maintaining a state of intersubjectivity. For example, the girl clearly reserves room for action, while disagreeing in her verbal communication. The shared space for interaction with their hands offers, and in this case even links, verbal interaction and movement together as fluent argumentation. Furthermore, this clip shows that the side-by-side positioning offers room for meaning making. In case of multi-touch, we expect that the girl would have touched the screen and started her manipulation without offering space, room, and time for the boy to finish his action.

Discussion

On the basis of our findings we argue that the constraints of a single touch-screen facilitate collaborative learning. By the same token, our findings indicate that having to share a workspace, despite the inevitable annoyance of not having your own, can lead to the establishing of rutines of turn taking, co-viewing and co-manipulating, which in the end can lead to intersubjectivity. Moreover, the side-by-side position, the single-touch condition, and the vertical position create a room for shared meaning making. As a result of this, we argue that researchers and teachers should consider whether single or multi-touch facilitates collaborative learning better. With the short sequence featuring Iris and Vince, we illustrated the way in which two children were making sense through language, gestures and with the material as a shared reference. The pair were prompted to reconfigure the scene to match their story. From our perspective, the missing rock was an important feature of the learning material. This discrepancy led the children to discuss and reinterpret the scene. This is where meaning making happens.

Ahead of us lie new technological developments that will influence the ways in which we learn and work. It might be tempting to trace the ever changing realm of technology. For example, invest in multi-touch tables or tablets for every individual learner in the schools. As we demonstrated in our analysis, the single-touch condition adds a seemingly interesting constraint that supported collaborative learning in this setting. We argue that researchers need to look for mechanisms of collaboration (e.g. Yuill and Rogers (2012)) in other settings in order to design touch technologies and learning materials that promote intersubjective meaning making.

Endnotes

(1) Names of each child, teacher and the school have been changed.
(2) Visit http://people.hum.aau.dk/~jackd/CSCL13/ to view the video and transcript analysed in this paper.

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Modeling #Twitter Use: Do Students Notice?

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Abstract: Despite the observed beneficial effect of Twitter on student engagement, interaction, and overall performance within different subject areas, little empirical evidence is available concerning the dynamics of students' activity on Twitter in an educational setting and which factors influence this activity. This study aims to observe whether the Twitter activity of preservice teachers differs in the presence of an instructor serving as a co-Tweeter. A total of six sections, each with approximately 20 students enrolled, of an educational technology course at a large research university in the United States participated in the study. We conducted a preliminary content analysis of student tweets from the first two months of the course. The analysis showed that students tend to model their Twitter activity on the model of the co-tweeting instructor, both in terms of the content of their tweets and their likelihood to use certain features.

Twitter is a popular social networking tool, enabling users to share short messages via computers and mobile devices. Public twitter users engage in message broadcasting; anyone can see the messages that they share, and their messages may be aggregated with those of other users based on search terms or hashtags (e.g., #tag). Twitter has been criticized for creating more noise than signal and for lacking depth or substance (Ebner, Lienhardt, Rohs, & Meyer, 2010; Suh, Hong, Convertino & Chi, 2010). At the same time, it has been identified as a potentially useful knowledge-sharing tool (Dennen & Jiang, 2012; Letierce, Passant, Decker & Breslin, 2010). For this study, Twitter was implemented in six sections of an undergraduate education class in an attempt to support knowledge sharing and community building across multiple course sections. We adjusted the instructor's presence to see how instructor presence and modeling can help shape student Twitter use in a class setting.

Background

Twitter has been of interest to educators because, like other social media, it holds the potential to support collaborative interactions and to foster both community building and knowledge sharing (Ebner et al., 2010; Junco, Heibergert & Loken, 2011; Lee & McLoughlin, 2010; Schroeder, Minocha & Schneider, 2010). Additionally, many educators have noted the popularity of social networking tools among their students in their everyday life activities (Merchant, 2012). In a formal education setting, Twitter has been used to support face-to-face learning environments (Elavsky et al., 2011; Rinaldo, Tapp, & Laverie, 2011) and to conduct out-of-class activities (Junco et al., 2011). However, relatively few studies document the use of Twitter as a learning tool in a higher education setting. Junco, Heibergert, and Loken (2011) observed a direct relationship between the use of Twitter to complement face-to-face classes and student grades and engagement. Rinaldo, Tapp, and Laverie (2011) observed a relationship between students' involvement and the use of Twitter to support in-class activities, make announcements, solve student issues, and perform course-related administrative duties. Furthermore, Dunlap and Lowenthal (2009) observed positive relationships between the use of Twitter as a ubiquitous communication tool, students' interaction, and social presence of the instructor in a distance learning setting.

Although these studies suggest a beneficial effect of Twitter on student engagement, interaction, and overall performance within different subject areas, research has not focused on the dynamics of students' activity on Twitter in an educational setting and which factors influence this activity. This study aims to fill this gap, and it is mainly directed to instructors and researchers interested in implementing Twitter as a tool to foster knowledge sharing and collaborative learning among higher education students.

Context, Purpose and Research Question

As Twitter-using educators ourselves, we believe that Twitter can be a useful tool for developing and maintaining a professional learning network. Rather than just suggesting to preservice teachers that they might use Twitter for post-graduation professional development, we desired to give them direct experience with how Twitter could be used to build and interact with a professional learning network. In earlier semesters using Twitter with these students, we found that participation was minimal and lackluster. Students engaged in little to no peer interaction, shared few resources, and at best met minimum posting requirements with little substance or knowledge sharing. However, we noted pockets of desired activity occurring in instances where there was an instructor presence (Dennen, Kim & Hsieh, 2011). The purpose of this study, then, is to observe whether the Twitter activity of preservice teachers differs in the presence of an instructor model. Of particular interest is whether students who have a model make greater use of Twitter elements that support knowledge sharing and management, such as retweets, hashtags, @replies, and URLs (Dennen & Jiang, 2012), than students who lack an instructor model.

Additionally, we looked to see if message content differs across the two conditions. Thus, our research question is: How does the presence of an active instructor who models knowledge sharing and community building via Twitter affect student use of Twitter across multiple sections of a university course? We hypothesized that an ongoing instructor presence that modeled appropriate tweets might encourage desired knowledge sharing and community building via Twitter within and across class sections. The findings of this study may help researchers and instructors interested in using Twitter as a learning tool—especially in a formal learning setting with periodical face-to-face meetings and a strong online component—to design Twitter-based learning activities that shape a specific behavior, promote knowledge sharing, and foster collaborative learning among higher education students.

Methods

Participants. The participants in this study were students enrolled in an educational technology course at a large research university in the United States. Most students were in education-related majors, although a few enrolled to meet a university computer course requirement. There were six sections of approximately twenty students each, and three sections were assigned to each condition. Participation was voluntary and had no bearing on student grades.

Study conditions. The study was incorporated into an existing semester-long Twitter participation assignment. Per this assignment, students were required to post an entry on Twitter on two different days each week during eleven weeks of the course, for a minimum of 22 tweets during the semester. They also were required to follow at least four Twitter accounts belonging to educators/educational technology experts; to use a common course hashtag at least five times to communicate with the whole class; to use other hashtags at least five times; to reply to at least five tweets using the @ function; and use the retweet (RT) function at least five times. Beyond these requirements, the content of posts was not constrained. Students were told that it was preferable to tweet about course-related topics, to interact with their classmates, and to share relevant resources. To foster student-student interaction in both conditions, we encouraged students to follow all of their classmates on Twitter in addition to following the course hashtag.

Two hashtags were used to aggregate tweets, one for the control group (three course sections) and one for the experimental group (three course sections). Control group instructors only replied to students if they received a direct question from students. Experimental group instructors could do same, but this group had the addition of an instructor-like person who tweets alongside the students and serves as a model. One of the researchers controls the experimental account, and regularly posts tweets to the experiment hashtag. These tweets modeled the desired use of Twitter (e.g., share relevant resources, interacted with course members).

Data Collection and Analysis

The primary data source for this study is the students' tweets, which were archived using HootSuite (hootsuite.com). Additional data sources include pre- and post-course surveys and student reflection papers. This brief paper focuses on a content analysis of the student tweets, with the survey data and reflection papers used for triangulation. Coding categories were emergent and developed by both researchers together after a preliminary review of the data. They fall into three main categories: Course related, school related, and non-school related. Table 1 presents the codes and an example of each code.

Table 1: Content analysis codes with examples of tweets.

Code	Example
Course related (CR) – Social / greetings	Happy Halloween everyone!
CR – Educational Technology	Looking forward to using Jing for the first time!
CR – Assignment – Commentary	Completed the blog post
CR – Assignment – Promoting work	Follow me on Wordpress! http://…
CR – Identity as a teacher	Seriously considering becoming an art teacher at the elementary level
CR – Class – Positive attitude	Ready for a little education to technology tomorrow. I love that class
CR – Class – Negative attitude	First skill check done. That was painful
CR – Class – Neutral attitude	Skill Check #1 officially done #holla
CR – Sharing resources (URL)	http://… Hey guys, a cool teaching opportunity. Creative writing w/ 9-11
CR – Asking questions	How do we find the prompts for the blog posts?
School Related (SR) - Sports	Let's go …!
SR – Other classes	Getting ready for my next class today
SR – Campus life / studying	Join the SFEA today! Includes personal liability insurance! http://…
Other	Feeling better today! #notsickanymore

Findings

At the beginning of the semester 22% of students in the control group and 36% of students in the experimental group were unfamiliar with Twitter. Further, 24% of students in the control group and 27% of students in the experimental group were uncomfortable with the idea of using it; those percentages dropped to 12% (control) and 7% (experiment) by the end of the term. After tweeting for a semester, students were not necessarily enamored with Twitter, but experimental group students were more likely in open survey questions to indicate that it was a valuable tool for interacting with others and also gave more in-depth and thoughtful critiques of using Twitter in a class setting.

Table 2 summarizes the total number of tweets written to the course hashtags by students across both conditions, and using each of the Twitter communication features. The overall number of tweets was similar within the two groups, which is not surprising given that students were striving to fulfill assignment-mandated requirements. Students in the control group were more likely than students in the experimental group to make use of the reply feature; this suggests that, in the absence of an instructor, students might tend to communicate more with each other. In contrast, students in the experimental group were more likely to retweet, especially the instructor's entries with links to online material inherent to the topics covered in class. However, the percentage of tweets that include a link is low for both groups, suggesting that students were not heavily interested in sharing resources with their classmates. When the students used additional hashtags, another feature that was not modeled, they used them expressively rather than for the purpose of aggregation with other related tweets. Examples of these hashtags are #everymonday, #help, #thatwaseasy, and #notsickanymore.

Table 2: Summary of hashtag and feature use by students (S) and instructor/researcher (I/R)

	Course hashtag		Other hashtags		Reply		Retweet		URL	
	S	I/R	S	I/R	S	I/R	S	I/R	S	I/R
Experiment (N=55)	505	68	98	0	14	11	92	3	14	43
%			19.4%	0%	2.8%	16.2%	18.2%	4.4%	2.8%	63.2%
Control (N=62)	534	14	93	0	35	3	74	0	15	5
%			17.4%	0%	6.5%	21.4%	13.8%	0%	2.8%	35.7%

Table 3 summarizes the content of students' tweets. Omitted from this summary are retweets, since they were not composed directly by the students. Interestingly, students in the control group almost entirely limited themselves to course-related topics, with most focused on providing a commentary either about an assignment or about the class in general. An examination of time stamps and tweet content indicated that most of the tweets were composed the day before class while the students were working on their other homework for the class (e.g., "Trying to figure out this assignment" and "Finishing my homework"), or, especially for the control group, during the weekly face-to-face class meeting (e.g., "Learning about wiki in #..." and "Making my own storybook in class"). The predominant attitude toward the class and homework was usually neutral ("Hoping the skill check in #... today isn't too hard"), with peaks of enthusiasm for tools explored in class ("I learn so much about technology in my #... class"). Probably because of the instructor's model, the percentage of the tweets about educational technology in general was higher for the experimental group than the control group.

Table 3: Content analysis codes and corresponding number and percentage of tweets posted by students of both conditions.

	Experimental condition		Control condition	
	Number	%	Number	%
Course related (CR) – Social / greetings	15	3.6%	18	3.9%
CR – Educational Technology	36	8.7%	21	4.6%
CR – Assignment – Commentary	161	39.0%	187	40.6%
CR – Assignment – Promoting work	11	2.7%	6	1.3%
CR – Identity as a teacher	6	1.5%	2	0.4%
CR – Class – Positive attitude	19	4.6%	32	6.9%
CR – Class – Negative attitude	8	1.9%	25	5.4%
CR – Class – Neutral attitude	43	10.4%	106	23.0%
CR – Sharing resources (URL)	12	2.9%	10	2.2%
CR – Asking questions	35	8.5%	18	3.9%
School Related (SR) - Sports	17	4.1%	6	1.3%
SR – Other classes	9	2.2%	1	0.2%
SR – Campus life / studying	9	2.2%	9	2.0%
Other	32	7.7%	19	4.1%
Total	413		460	

The content of the tweets suggests that students were aware of the presence or absence of an instructor. In the control group, students were more likely to post negative sentiments. In the experimental group, they were more likely to ask questions and post about educational technology in general. Students in the experimental group also were more likely to engage socially on the hashtag, not restricting themselves to course-related content.

Discussion and Conclusion

These findings suggest that the presence of a co-tweeting instructor does affect how students use Twitter. Students in the experimental condition had a higher tendency to focus on course-related topics, much as the instructor model did. However, one unintended effect was the student's orientation toward the instructor in the experimental condition; rather than interacting with each other more, students engaged in activities that centered around the model account (e.g., retweeting the model tweets). At the same time, in the absence of an active instructor students more freely shared their thoughts about the class. Thus it seems likely that students were clearly aware of the presence or absence of an instructor in this activity. In other words, instructor presence seems to have influenced both the content of student tweets and students' likelihood to use certain features. Following their co-tweeting instructor's model, students in the experiment group were more likely to support knowledge sharing and community building within and across class sections than students of the control group.

Based on these findings, we recommend that instructors who implement Twitter with their students be mindful of their desired outcomes and then actively and consistently model the types of tweets and interactions that should lead to those outcomes for their students. Providing a static model in the assignment directions is not sufficient to influence student actions over the course of the semester; an ongoing, dynamic model provides students with a continuous reminder of how to complete the assignment. However, student tendency to focus on interacting with the instructor over each other is concerning and could limit the development of an ongoing personal network on Twitter. In future iterations, we plan to adjust the instructor model to include interactions that should explicitly connect two or more students.

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Student Strategies for Collaborative Note-Taking and the Influence of Floor-Control

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Abstract: In this paper, we examine student dyads' emergent collaborative note-taking practices in a shared text editor during face-to-face project meetings. We describe the individual actions that students perform and show that turn-taking rather than simultaneous access is the most common collaboration strategy. We identify *implicit round-robin* and *complementary interruption* as two policies regulating the turn-taking strategy. We also investigate floor-control mechanisms, showing that dyads with free access trade turns at a higher frequency, and that the tendency towards turn-taking in this blended learning situation may lessen the need for floor control mechanisms. Overall, we find that collaborative note-taking as a pedagogical practice provides rich opportunities for epistemic deepening and tight collaboration between students.

Introduction

Note-taking, in the right circumstances, can become a tool for conceptual change and knowledge construction (Castello & Monero, 2005). Studies of collaborative note-taking have typically involved environments in which students are working simultaneously, with access to each other's notes on a collaborative whiteboard (e.g., Kam et al., 2005), rather than situations in which students are collaboratively writing to produce a single text.

Floor control has been shown to be a positive influence on collaboration, channeling the possibilities for chaos inherent in collaborative and distance learning environments into a situation which is more similar to the structure of face-to-face discussion (Schwarz & Glassner, 2007). McKinlay, Procter, Masting and Woodburn (1994) show that discussion through a chat with turn-taking proves better for producing consensus than discussion through a chat with free for all access. Floor control can also be a source of frustration, drawing discussion focus away from the task and onto turn-taking (Harris *et al*, 2009).

In this paper, we examine students' emergent collaborative note-taking practices using a shared text editor with two forms of floor control during face-to-face project meetings with their tutor. We describe a typology of individual actions students undertake and illustrate the ways in which they combine to form overall collaboration strategies for note-taking. We show that the presence or absence of a floor-control mechanism has a significant influence on the collaboration strategies which emerge. In conclusion, we first discuss the appropriateness of collaborative note-taking, both as a pedagogical tool to foster epistemically rich collaboration, and as a fertile terrain for research into joint meaning-making. We also discuss the role of floor-control mechanisms in regulating productive collaborations.

Individual and Collaborative Note-Taking

Castello & Monero (2005) describe note-taking along two dimensions with regard to the original content: in terms of relevance and coverage, notes can be *comprehensive*, *incomplete* or *selective*; in terms of form, notes can be *literal* or *personalized*. They find that students who consider the act of note-taking as a method to store information tend to take literal, comprehensive notes, while students who consider note-taking as an act which helps them better understand the topic tend to take personalized, selective notes, using different procedures to elaborate upon and organize information. Better students incorporate four key practices: organizing and structuring information in a *personal* way; *amplifying* content by relating it to existing knowledge and resources; *reflecting* by adding information and comments; *synthesizing* by paraphrasing and including only relevant information.

Kam et al. (2005) investigate students' appropriation of an environment in which collaborative annotation of teacher slides on a shared whiteboard is possible, contrasting it with a single-user contribution. This form of collaborative note-taking allows simultaneous contributions (there is no floor control), but makes it difficult for students to edit and transform either their own or other people's contributions. They define a unit of annotation which they call a *mark* as "a spatio-temporally contiguous segment of pen-strokes or keyboard entries by one user to express a single logical idea." (p. 4). They draw up a typology of five kinds of marks. *Note-taking*: someone taking notes on the lecture. *Commentary*: someone making a statement, as opposed to recording notes. *Question*: someone soliciting a response. *Answer*: answer to a question or clarification to some confusion. *Reinforcement*: someone's encouragement or response to others' comments

They find that students can overcome the limitations inherent to a single note-taker, for instance, by adding new notes while another student is still transcribing earlier lecture statements. They can take turns authoring notes, allowing other students to pay better attention to the lecture (they call this behavior *synchronized, turn-based note-taking*). They can also ask questions and seek additional information if they are confused or think they have missed something. Students in a collaborative note-taking condition took better quality notes in terms of content amplification and reflection and more varied notes in terms of the presence of commentary and questions.

In this paper, we begin to examine to what extent these results on collaborative note-taking on a shared whiteboard apply to collaborative note-taking in a shared text editor. Our first research question is, will we find the same forms of marks (individual actions) for note-taking in a shared text editor as in a shared whiteboard? Our second research question is what collaboration strategies will emerge in note-taking in a shared text editor? Our third research question concerns the effect of a floor-control mechanism on the collaboration: does it help in regulation of the interaction; does it provoke more reflection and planning?

Empirical Study: Student-Tutor Meetings for a Programming Project

We observed nine dyads during the first meeting (and up to 4 subsequent meetings, not analyzed in this paper) with their tutor for an introductory-level computer-programming project at a French university. These meetings took place face-to-face with the assistance of a synchronous shared text editor, visible on laptops by the two students and the tutor. This study was pedagogically motivated by a desire to see students actually take notes during these meetings and define tasks to be accomplished before the next meeting in a way that was visible to all participants, in opposition to the situation of past years where students often did not make progress from one meeting to another.

Data collected for each session includes audio, video, the interaction log-file produced by the shared text editor, and field notes taken by an observing researcher. There were three different project topics and two tutors involved (one tutor supervising three groups and the other supervising six).

We also wanted to examine the role of floor control and compared two forms of shared text editor: with and without floor control. The first form in our study (used by 5 dyads) is a free-access text editor, which allows participants to write concurrently with no conflict, unless they are attempting to insert text at the same point. The second (used by 4 dyads) provides a token-based floor control mechanism, requiring participants to request and relinquish the "token" which gives permission to edit the shared text editor.

Analysis and Results

The data was analyzed with Tatiana (Dyke, Lund, & Girardot, 2009), which provides the means to replay the note-taking in the text editor, synchronized with the video, transcriptions, and log files, and to construct new analytic representations. In the replay mode, the text is colored by user to assist analysis, whereas during the actual study, color fades over a 20s period. The character-by-character log data for the shared text editor was abstracted into *marks*, adopting the terminology of Kam et al. (2005): a mark is a single logical idea or action, expressed in a spatio-temporally contiguous series of keystrokes. The main forms of spatial non-contiguity we found were: the use of new lines to initiate a new idea; the use of parentheses to add clarification, elaboration or reflection; the use of periods to construct sentences; and the use of colons in preparation of an enumeration. Other forms of mark consisting of a unique action included copy-pasting, formatting and editing.

In this analysis, in answer to our first research question, we look at the kinds of marks the students contributed and refine the typology defined by Kam *et al.* in order to categorize the various marks. We then, in answer to the second research question, examine the collaboration strategies that emerged and the situations in which turn-taking occurred. Finally, in answer to the third research question, we examine the effect of the floor control condition on these collaboration strategies.

Research Question 1: Individual Actions Performed During Note-Taking

The main difference between our situation and that of Kam *et al.* is the nature of a shared text editor. Unlike with a shared whiteboard, which comprises multiple different objects, a shared text is a single object with a natural insertion point for new material (the end of the text), and which can be edited at other points, by inserting or removing characters. As such, we introduced a top-level distinction between marks affecting the *content* of the text and those which do not contribute new content (i.e., various forms of *editing*).

Among the editing marks, we distinguished three categories: editing of *spelling*, editing of *formatting* and *other* (typically false starts). Among the content marks, we found two dimensions of distinction: position and type. The position dimension comes from the nature of a shared text editor: sequential marks occur at the natural insertion point (typically the end of the text, except in circumstances where text is deliberately spatially demarcated); inserted marks add commentary or elaboration to earlier contributions, returning to a different area of the text than the natural insertion point. The type dimension is similar to that of Kam and colleagues. We find *note-taking*, *commentary*, *questions*, and *answers*. In addition, we find two new categories: *fragments* and *word selection*. *Fragments* are *note-taking* marks which are temporally but not ideationally demarcated (i.e., they do not, on their own, constitute a single logical idea, but cannot be associated with other content written contiguously in time by the same author). Such fragments are typically elaborations on previous content. We also find *word selection*, only in inserted marks, where a word or phrase is replaced by another apparently more appropriate one. We would expect to see another two hypothetical categories, *deletion*, where content is removed, and *reinforcement* (reported by Kam *et al.*), where one user encourages or responds to another user's commentary. There were, however, no deletions in our corpus, unless false starts might be counted as such, and no reinforcements.

The majority of marks in our corpus were sequential note-taking (65%). Next come various forms of editing: spelling (7%), formatting (8%) and other (6%). Inserted content is rare overall (totaling 4%), as are fragments (totaling 8%), the remainder being made up of other categories.

Research Question 2: Collaboration Strategies and Policies Regulating Turn-Taking

The overwhelming majority of the collaboration strategies we observed occurred without explicit planning. Overall, collaboration was of good quality with students in all 9 groups contributing actively to the joint note-taking process, apparently having little problem achieving alignment and agreement (Baker, 2002). Because of the improvised nature of the collaboration, it was rare for students to adopt fixed roles. *Sequential single writing* (Lowry, Curtis & Lowry, 2004), where one group member writes at a time, was the most common strategy, along with occasional *parallel writing*, either in distribution of "assignments", such as being responsible for a topic, or of roles, such as editing to adjust formatting and spelling. In each group, the variety of practices (e.g., organizational formatting with numbers, elaboration with parenthetical fragments, correction of spelling) was small, but when a practice did occur, both students tended to adopt it.

The only exception to the general strategy of sequential single writing, was a group for whom an initial attempt at simultaneous writing at the same point resulted in conflict. This led one student to demarcate two zones, one for each student's notes. They then proceeded to take individual notes. Aside from this exception, none of the groups took advantage of the possibility of simultaneous editing in more than a few isolated instances, tending instead to trade turns, in both floor control and free access conditions. This is consistent with the strategy of *synchronized, turn-based note-taking* found by Kam and colleagues. We observed two main policies that seemed to regulate a change of turn. The first is *implicit round-robin*: when a student has finished authoring a note-taking mark (or a small, thematic collection of marks), it is no longer "their" turn and authorship switches (without explicit coordination) to the other student. This was the initial policy adopted by 6 out of 9 groups and was used by all groups at some point or other. The second policy, also found in all groups is *complementary interruption*: when a student keeps the authorship for a period of time, the other student appears happy to let them be the note-taker, until a point at which they feel that something has been overlooked; they then interrupt, adding the complementary information and often becoming the *de facto* note-taker at that point. Unlike the loose cooperative behavior described by Kam and colleagues, where turn-taking seemed to occur when the group saw that the teacher had moved on to a new topic before the current note-taker had had time to write everything down, the two policies which regulate the overall turn-taking strategy we found indicate a much tighter collaboration, with constant maintenance of alignment and agreement.

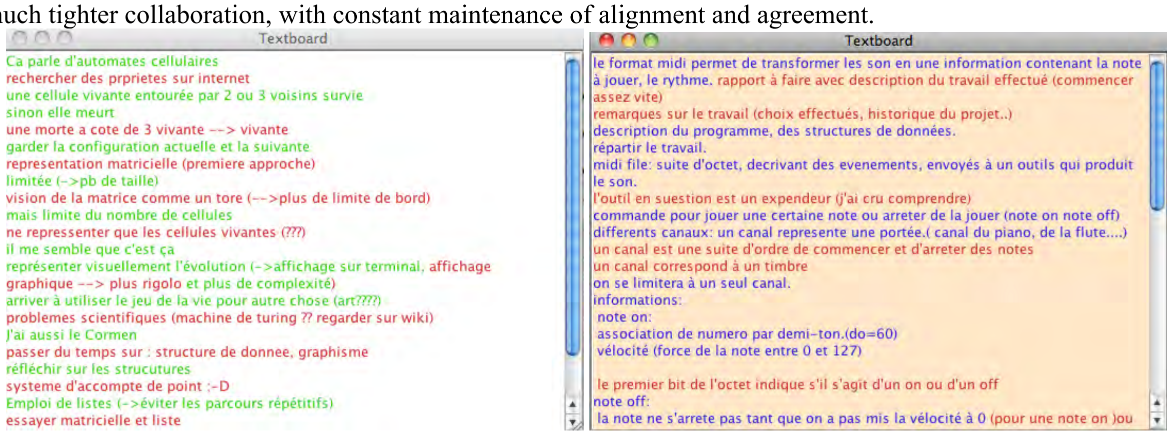

Figure 1. Typical note-taking with free access (left) vs. floor control (right), colors indicate which student authored the text.

Research Question 3: Effect of Floor Control on Collaboration Strategies

In neither condition was there much explicit planning or coordination, with the exception of a few requests for the other student to release the floor in the floor control condition. However, when examining the final products in the two conditions, we noticed an overall effect that in the floor control condition, the size of chunks of text (consisting of multiple marks) by a single student seemed bigger. This is illustrated by the comparison in figure 1. Because of the turn-taking mechanism, it seems that an authoring student has more inertia, thus writing longer, regardless of whether the turn change happens because of complementary interruption or implicit round-robin. In order to validate this emerging hypothesis, we counted the number of consecutive content marks by different authors and calculated their proportion in terms of total content marks for the 8 groups which used turn-taking. We found that the free access groups *all* had higher proportions of turn changes (median value 42%) than each of the floor control groups (median value 23%). Although this sample size is too small to read much into the result, this difference is significant according to the Wilcoxon rank-sum test (U=0, n1=n2=4, $p<0.05$). We have not yet, however, found in a difference between groups in the quality of notes, or in the quantity of reflection and planning.

Discussion and Conclusion

For all the groups analyzed in this study, our pedagogical goals were met: students came away with a record of their meeting and a contract for the next meeting. Furthermore, there are advantages to the tutor in seeing these notes: gauging students' comprehension and engagement, and being able to respond to their comments and questions, expressed through the back channel of the shared text editor.

In answer to our first research question, by investigating the kinds of marks created during the collaborative note-taking, we have highlighted the opportunities for epistemic deepening present in this kind of situation, surpassing even the reported advantages of taking notes on a shared whiteboard. Indeed, *inserted* marks in general, *word selection*, and *fragments*, create greater opportunity for *personalization*, *amplification*, *reflection*, and *synthesis*, the positive qualities described by Castello & Monero (2005). However, we also found that the rate of adoption of these opportunities was not high and that note-taking practices had a strong inertia, indicating that we cannot necessarily expect students to develop optimal practices (for either good note-taking or productive collaboration) when appropriating a shared text editor for collaborative note-taking, without scaffolding or prior instruction. However, these opportunities for epistemic deepening suggest that collaborative note-taking is a promising pedagogical instrument in CSCL settings.

In answer to our second research question concerning the types of collaboration that would emerge, each of these records was a jointly constructed artifact, resulting from a collaboration in which both members of each student dyad were invested. The most common collaboration strategy of students (in both conditions) was taking turns, with limited amounts of revision. This is similar to the *synchronized, turn-based note-taking* found by Kam et al (2005), but the policies of *implicit round-robin* and *complementary interruption*, which we identified as regulating turn-taking, require a deeper collaboration.

In answer to our third research question, we found an unexpectedly strong effect of the floor control condition. We expected the floor control mechanism to have a structuring effect on the collaboration. However, either because of the nature of the situation (blending face-to-face with computer-mediated collaborative note-taking), or because of the nature of a single text (as opposed to a whiteboard), turn-taking was already the preferred strategy. In such a situation, there is perhaps no need for a floor-control mechanism. This indicates that for other CSCL situations, both technological and situational affordances might be a means for scaffolding productive collaboration, without having to resort to floor-control mechanisms.

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A Multidimensional Dialogic Framework in Support of Collaborative Creativity in Computer Programming

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Abstract: Although in computer programming creativity is required, teaching methods applying tasks that address creative aspects are scarcely reflected in computer science education. This paper describes a multidimensional dialogic framework in support of creativity in programming and the results of a successful computer science experiment, where the teacher facilitates the development of programming skills by means of the students random involvement in collaborative and creative dimensions of the framework. The teacher is called to pay attention in a great repertoire of productive interactions that enables him/her to promote creative programming activities. The framework presented here involves underlying dialogic processes from seven collaborative and creative dimensions that allow students to develop both adaptive and innovative creativity in programming. Students can simultaneously activate two or more ideas, images, or thoughts and have them interact, prompt thought experiments, change cognitive perspectives, raise new points of view, and risk category mistakes during computer programming.

Introduction

Teaching creativity is an important endeavor in computer science education. Although in computer programming creativity is required, teaching methods applying tasks that address creative aspects of programming are scarcely reflected in computer science education research. Despite students should be fostered to develop and apply their creativity, computer science education researchers and teachers does not approach creativity very often. In this work we develop and apply a contextualized dialogic framework to foster creativity in introductory programming courses. During program design, the teacher evokes dialogic processes to trigger exploratory discussions among students. Such students´ discussions have the potential to facilitate the formation of various connections among different programming aspects that propitiate the emergence of creative programmers.

Learning programming demands abilities to combine language features to create computational solutions. Here, we go beyond language features and its combinations. The dialogic pedagogical approach embraces the application of programming patterns and anti-patterns as an important aspect of creative processes during program design. Under this perspective, programming design skills also involves abilities to blend patterns and language features to construct programs. Some studies (Robins et al., 2003; Muller et al., 2004; Soloway & Ehrlich, 1984) show that programming expertise is partly represented by a knowledge base of pattern-like chunks. Programming patterns are are solutions to basic recurring algorithmic problems and form the building blocks for the development of programs.

The use of the pedagogical dialogic framework presented here makes possible exercise both innovative creativity, that is original, transformational, and expressive and adaptive creativity that is logical, adequate, and well-crafted. Programmers can be able to adapt and combine programming patterns, making use of pieces of knowledge well-crafted done by experts, but also be able to create their own new solutions or new patterns for a computational problem blending programming patterns and programming language knowledge development in many creative directions.

Dialogic Approach for Teaching and Learning to be a Creative Programmer

Wegerif (2010) proposes an educational dialogic theory of thinking and teaching thinking, which starts from the metaphor of thinking as dialogue. Dialogic education means teaching for dialogue as well as teaching through dialogue. Under dialogic education perspective, thinking is understood not as some kind of thing but as a kind of relationship that expresses a way of responding to other´s ideas and to new possibilities. He advocates that by teaching students to engage more effectively in complex and meaningful dialogues with others we are teaching them the essence of thinking and proposes a scaffolding approach to teaching thinking as opening, widening and deepening a dialogic space. Students are engaged in a widen dialog space when they are better acquainted with the range of positions that are possible and they deepen a debate when they are able to go deeper into a single bit of the argument to explore its assumptions and implications.

Considering as a starting point Wegerif´s educational dialogic theory, we elaborate in this work a pedagogical dialogic framework for teaching creativity. A dialogic process comprises thinking and discussion, generating a verbal description of the thinking process. The ideas created underneath dialog processes can be developed in other dialog processes. Dialogic processes explicitly prompt students to be aware of possible ways to create and improve an idea, opening, deepening and widening the dialogic space. We propose the following seven kinds of transformations of dialogic space: immersing, unpacking opportunities, overcoming boundaries, expanding, discovering unpredictable places, and developing.

Dimension 1. Immersing in Programming

Students can widen the design space while discuss having in mind search information having an objective in mind and search information for inspiration, detect relevant and irrelevant information, recognize familiar information and cope with new information, and reapply techniques and adapt techniques.

According to Jonassen (2010), when students scrutinize similar problems for their structures, they gain more robust conceptual knowledge about the problems, constructing stronger problem schema. This dimension concerns with the enhancement of the analogical thinking. Analogical reasoning involves the transfer of solutions from previously known problems to novel ones and the ability to abstract similarities and apply previous productive experiences to new situations. This dimension is also concerned with the search for information. To be successful at discovery and innovation students should be aware of previous and related work and should be aware of principles and techniques to be applied in the development of their work. The more diverse your knowledge, more interesting is the interconnections. In this dimension, given a computational problem, during program design, debug, and re-design, some dialogic processes are: detect programming patterns to be adapted, making connections between problem kind and previous knowledge pieces, adapt patterns to various problem´s constraints, check if minor but essential patterns modifications were not neglected, verifying if not only the main pattern function was considered, i. e., the secondary aspects were not omitted, perform simple mappings of patterns and major patterns´ modifications, approach the problem systematically, and predicting the mixing of patterns, sequence actions, choices and iterations.

Dimension 2. Unpacking Programming Opportunities

Students can deepen the design space when discuss while collaboratively look for attributes and relationships among concepts and new ideas, and try to organize the information, recognize dependence and independence relations, necessary and sufficient conditions, causes and effects, similarities and differences, correspondences and oppositions, class inclusion and exclusion, associations and dissociations, hierarchy ascendant and descendant relations, order and disorder, abstract and concrete features, potential and non-potential uses/functions, examples and counter-examples, and make an interplay between concrete and abstract features.
Guilford (1967) advocates that elaboration and fluency are two fundamental components of the creative process. This dimension embraces the divergent thinking abilities elaboration and fluency. The teacher can boost the students´ improvement of these abilities to explicit what is already there but hidden and also to deal with the who, what, why, and how elements of solution ideas. In this dimension, given a computational problem, during program design, debug, and re-design, some dialogic processes are: establish interconnections among patterns and observe connections between patterns and problems, generalize the examples given by the teacher being able to understand a pattern, avoid specialization problems, in which patterns are maladaptive, and search patterns examples.

Dimension 3. Overcoming Programming Boundaries

This dimension is related to an attempt to overcome and visualize concepts and ideas in an open minded way. This dimension widens the dialog space. The students situate ideas in a bigger context and perform contextual shifting. Jointly search for indirect and direct factors, relationships with “neighbor” ideas outside a given context, visualize scope, limitations, and constraints, in an attempt to overcome it. Seeing an idea in different contexts and also seeing ideas in a bigger scenario is a way to overcome conceptual barriers, gain insight about other possible uses and meanings, recognize indirect and direct factors, bigger and smaller context, limitations and ranges, constraints and lack of constraint, state a context and contextual shifting, and state a point of view and change a point of view. Guilford (1967) advocates that flexibility is a fundamental component of the creative process. This dimension embraces the divergent thinking ability flexibility. In this dimension, given a computational problem, during program design, debug, and re-design, some dialogic processes are: think about consequences of bad use of patterns, approach programming by significant control structures and patterns, trying to develop and the program as a whole or by means of significant parts and search for representative context of patterns usage.

Dimension 4. Expanding Programming

This dimension entangles constructive interactions among students related to innovative construction of a complex system of ideas. This dimension widens the dialogic space. Students make together re-combinations and combinations of similar or distinct of concepts and ideas, try to make combinations of possible disparate or unconnected ideas by means of a dialectical synthesis or encapsulating the entire dimension of a new concept, derive new knowledge on the basis of a lack of similarity between two or more past constructs or elements from domains which are far apart, make integrations and identify elements, broke and recombine ideas, make usual and unusual interpretation, produce an idea and point the lack of new ideas, and make predictions and findings. Dewey (1929) defined inquiry as a set of operations by which an indeterminate situation is rendered determinate. When participants engage in inquiry together, new meanings are created as a co-production. In this dimension, given a computational problem, during program design, debug, and re-design, some dialogic processes are: develop a repertoire of patterns suitable for adaptation to new formal systems, being aware that patterns emerge from the merging of two or more commands, be aware that programs are combinations of language features and patterns, that language features govern the patterns composition into programs, fit in sequence, nest and merge patterns, check if patterns interactions were not neglected, avoid wrong analogies that emerges from previous experience, given a pattern try to glimpse distinct related aspects like different use contexts, interpret program code, analyze previous patterns interpretations, composition with other patterns, and common misuses.

Dimension 5. Developing Programming

This dimension encompasses the evaluation, critics, and bringing together of ideas. One important aspect of this dimension is that when students evaluate and critique different perspectives and ideas they must be confronted with uncertainty and conceptual conflict. Both are states of disequilibrium that activate a process of conflict resolution and a quest for certainty (Dewey, 1929). Here students deepen and widen the dialogic space. They evaluate, compare, select concepts and ideas, consider different alternatives, and point positive and negative outcomes. They carry out decision making processes in function of criteria application. Here, we consider that a pattern is more efficient than other if it contains less instructions and operations. Given a computational problem, during program design, debug, and re-design, some dialogic processes are: try to improve pattern efficiency, check if the pattern is concise, brief, clear, and legible, compare right patterns and pick the best solution according to efficiency.

Dimension 6. Discovering Unpredictable Places in Programming Solutions

This dimension is related to the exploration of bad ideas and mistakes. The teacher deliberately encourages students to systematically analyze bad and wrong ideas with the aim to develop good ideas from bad ones and learn from mistakes. This dimension capitalizes on often way in which bad ideas become beneficial detours to good ideas. The exploration of good ideas allows a local exploration of the dialogic space, which leaves unexplored large areas of this space (Dix et al., 2006). The exploration of bad ideas pulls the students to new unpredictable places, facilitating a movement to far away places, which thus allows students to overcome the limitation of exploration that good ideas entail. In computer programming context, bad and wrong ideas are recurrent and can be instantiated by programming anti-patterns. In this dimension, the dialogic processes involve programming anti-patterns.

Dimension 7. Exploring Complementary Paths in the Design Space

This dimension involves complementarity. Here, we elaborate dialogic processes based on Ponty´s notion of “chiasm” (Ponty, 1968). In Ponty´s notion of “chiasm,” two concepts emerge as complementary ways of referring to an idea. For example, both sides, figure and ground, depend upon each other and can reverse around each other. This divergence is considered to be a necessary and constitutive factor in allowing subjectivity to be possible at all. However, he suggests that rather than involving a simple dualism, the divergence between touching and being touched, or between the sentient and the sensible, mind and body, subject and object, self and other also allows for the possibility of overlapping and encroachment between these two terms. The teacher is called to elaborate the students´ tasks based on complementary concepts.

Assessment of the Dialogic Framework for Programming

For this study, a teacher of an introductory programming course applied traditional course approach in the first part of the course, but asked the students to build programs in groups. In the second part of the course the teacher used the dialogic processes of the framework to prepare programming activities, present content and scaffold students. The teacher presented some program exemplifying programming patterns, presented examples of programming patterns adaptation and combination, provided problems that requires minor and major patterns adaptations and combinations, and motivated students to discuss the solutions that emerged from the group considering dialogic processes during programs planning, debug and evaluation. This mediation process focuses mostly on adaptive creativity in programming. The teacher also presented and analyzed some anti-patterns related to students’ misconceptions of students concerning program efficiency. The teacher provided some examples of programs that perform the same tasks comparing their efficiency. Afterwards, the teacher asked for each student in the group to solve new kinds of problems and motivated the group to discuss the partial solutions and also to discuss the entire innovative solutions in order to choose the best solution during patterns evaluation. This mediation process focuses mostly on innovative creativity in programming.

There were forty undergraduate students from food engineering course. During four months, the data analyzed were programs collaboratively created before and after framework application. The programs were evaluated considering students success in adapting and innovating program codes. First, the observed data was students´ manifestation of language-based anti-patterns, such as sequence, interpretation, inconsistency, and analogy problems. Second, we analyzed pattern problems, i. e., students´ inability to properly combine, specialize, optimize, and visualize details during patterns adaptations. Third, we checked students´ skills to develop solutions to new problems, measured by means of innovative program code generated. Students solved alone and in group 75 problems before framework application and 75 problems after framework application. The experiment results showed that after the teacher application of the dialogic framework language-based anti-patterns and patterns problems decreased while innovative program code generated increased. Statistical overview of the results obtained is shown in Table 1.

Table 1: Statistical Overview of the Results Obtained.

Data after Dialogic Framework Application	Decrease	Increase
Anti-patterns	50,00%	
Patterns problems	42,00%	
Innovative program code		35,00%

Conclusion

The preliminary results indicated that the dialogic dimensions presented here have the potential to allow students collaboratively and creatively explore important problem solving strategies. Students can simultaneously activate two or more ideas, images, or thoughts and have them interact, prompt thought experiments, change cognitive perspectives, raise new points of view, and risk category mistakes. They explore a multi-dimensional space of possibilities of deepening and widening the dialogic space.

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Common Knowledge: Orchestrating Synchronously Blended F2F Discourse in the Elementary Classroom

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Abstract: This study reports on the continued development of Common Knowledge (CK) – a pedagogical and technological innovation that supports knowledge building blended discourse. Students use handheld tablets to contribute notes to a community knowledge base, which is publicly displayed on the classroom's interactive whiteboard (IWB). This aggregate display provides students with a powerful visualization of the community's idea flow. The IWB display further provides teachers with "at-a-glance" formative assessment of students' thinking and supports spontaneous adjustments to their orchestration of inquiry activities and blended discourse. This paper presents a study of how CK supports student and teacher discourse in inquiry science.

Introduction & Objectives

A powerful genre of technology for learning involves the capture and representation of student ideas to promote richer discourse in the classroom, collective inquiry, and the growth of ideas (Hakkarainen, 2004; Scardamalia & Bereiter, 2006). This study reports on an innovative technological approach called Common Knowledge (CK), where students use handheld tablet technology to contribute notes arising from their science inquiry, which get dynamically displayed on the classroom's interactive whiteboard (IWB) to facilitate further student- and teacher-led oral discourse. This paper describes how CK supports student reflections and helps teachers guide collective, idea-centred inquiry in elementary science.

Theoretical Foundations

The present research is informed by the theoretical notion of classrooms as Knowledge Communities. Knowledge Building engages student knowledge communities in discursive activity (Scardamalia & Bereiter, 2006), and Knowledge Forum scaffolds asynchronous online discourse (Scardamalia, 2004). Adding a scripted inquiry (Raes et al., 2012) dimension to the knowledge community approach, Slotta and his colleagues have advanced the Knowledge Community and Inquiry model (KCI - Slotta & Najafi, 2012), where students contribute to a collective "knowledge base" which becomes a resource for inquiry activities targeting specific learning goals (Peters & Slotta, 2010). KCI provided a theoretical perspective for the present research. Teachers in this study are veterans of the Knowledge Building approach, which provided further theoretical grounding for our emerging ideas about blended discourse and knowledge building processes within a smart classroom's KCI curriculum.

If language mediates children's thinking and learning (Hicks, 1995), it follows that students working within a knowledge community use language (ideas, utterances, etc) to generate new meaning (Wertsch & Smolka, 1994), with interpersonal communication leading to the development of learners' cognition (Sfard, 2007). Thus the role of discourse in teaching and learning may be viewed as social meaning construction - a necessary aspect of children's conceptual development, by Vygotskyan accounts. Collaborative knowledge construction can occur via asynchronous online discourse and synchronous face-to-face (F2F) oral discourse, if pedagogically-sound technological and teacher scaffolding are provided (Greeno, 2011; Linn & Slotta, 2006; Scardamalia & Bereiter, 2006). Several researchers have developed design principles for learning environments (Engle & Conant, 2002) and orchestration (Penuel et al., 2012) that foster productive spontaneous and ongoing discourse (Lemke, 2009). Indeed, a group's online discursive progress emerges from accumulated spontaneous individual actions (Wise et al., 2012).

Computer-Supported Discourse for Collaborative Learning

A variety of projects have tapped into the potential for technology to script discourse for F2F collaborative learning. The Peer Instruction approach with clickers (Crouch et al., 2007) uses a participant structure to scaffold discourse. CollPad (Nussbaum et al., 2009) uses Pocket PC touch devices deliver collaboration scripts that facilitate reciprocal problem solving. A ‘collaboration script’ is a set of instructions for how learners interact with one another, and how they approach a task (Dillenbourg, 2002). These approaches add some “orchestrational load” to the teacher, in terms of guiding inquiry discourse informed by their real-time monitoring of the community’s idea flow, while simultaneously managing the classroom and engaging in multiple small group interactions in rapid succession. Hence, discussion productivity relies upon a teacher’s talent for on-the-fly analysis and facilitation. Furthermore, the approaches to date do now typically allow learners to access the individual contributions of peers - inhibiting learners from forming a complete picture of the community’s collective idea flow.

Technological advancements over the past 2 decades have led to the development of extensible messaging and presence protocol (XMPP) affording real-time instant messaging and co-authorship (e.g., Google Docs); as well as “smart classroom” infrastructure enabling pedagogically-oriented scripting to support a distributed array of classroom technologies (Slotta, 2010), for collective and individual inquiry (Raes et al., 2012). “Blended learning” has traditionally been defined as the combination of asynchronous online learning activities with F2F learning (Graham, 2009), and the *act* of “blending” has been asynchronous until now. Our work leverages these technologies for *real-time blending* of F2F synchronous online discourse with F2F oral classroom discourse – hence our term “synchronously blended F2F discourse”. This project explores the orchestration of real-time blending of the two discursive modalities. We report on an ongoing program of design research (Collins et al., 2004) to develop a technological and pedagogical innovation known as Common Knowledge (CK), a handheld computer tablet and IWB system enabling student note contribution of questions, theories, and ideas; and “tagging” of these. Notes dynamically appear on tablets and the classroom’s IWB, allowing teachers and students to drag notes into topic clusters during oral discussions, swiftly filtering topics as the discussion progresses. By conceptually connecting student reflections, CK provides new pedagogical opportunities for teachers and students to progress on their collective understanding and engage in inquiry practices.

Method & Data Sources

Data sources from our classroom observations included field notes, video recordings, teacher and student interviews, and data logs of CK discussions. We analyzed the data in terms of teachers’ orchestrational and discursive scaffolds (Fischer & Dillenbourg, 2006; Fong et al., 2012; Prieto et al., 2011). Participants were 2 veteran grade 5/6 teachers, ‘Brad’ and ‘Jen’, in a private elementary school located in a large Canadian city, with 21 and 22 students, respectively (approximately equal numbers of grade 5 and 6 students). Brad had been teaching for 8 years, and Jen for 4 years. The school has an emphasis on inquiry and Knowledge Building pedagogy. Students were engaged in a broader inquiry biodiversity curriculum – WallCology Embedded Phenomena – within which the present study was deeply integrated. In WallCology, students were tasked with investigating a virtual ‘live’ ecosystem located within their classroom’s walls (Moher & Slotta, 2012). We integrated CK discussions into this inquiry curriculum, specifying discussion goals (Nussbaum, 2005) and pre-programming science content and process keyword tags. Teachers also launched spontaneous CK discussions, as they felt warranted.

Findings and Discussion

The goal was to produce a schema for productive inquiry discourse that informs future iterations of CK and the scripting of its enactment. A grounded theory approach was used, to see what orchestrational patterns emerged from classroom enactments. We observed that student CK contributions displayed on the IWB spurred a variety of teacher discourse moves. These moves were coded from video analysis using Fischer & Dillenbourg’s (Fischer & Dillenbourg, 2006) 3 dimensions of orchestrational coordination (cognitive, pedagogical, and technological), as well as a fourth dimension, “curricular”, capturing teachers’ direct treatment of the subject-matter content (Figure 1).

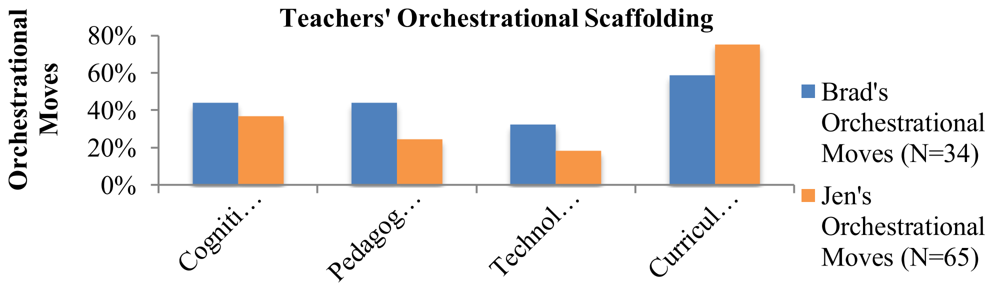

Figure 1. Teacher coordination of discourse in their classrooms.

Video analysis revealed an ongoing cycle of "Release Redirect Reflect Refocus (4Rs)" orchestration cycle, for managing synchronous CK and oral discussions. Throughout this cycle, a grounded theory approach to coding teachers' individual speech turns revealed some prominent discursive moves (Figure 2): "Technology Instruction (TI)", "Solicit Ideas (SI)", "Encourage Hypotheses & Theories (HT)", "Resolve Divergence (RD)", and "Motivate Alternative Approaches (MA)".

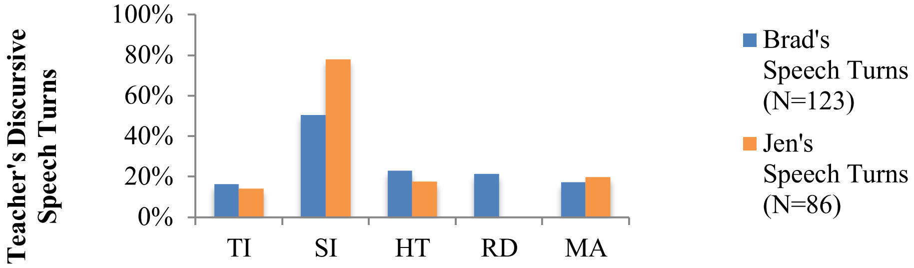

Figure 2. Teachers' discursive moves.

Within the "Reflect" phase of the cycle, teachers' speech turns revealed several types of revoicing or repeating, paraphrasing, or referring to a student's written or spoken contribution to position students in relation to each other and to the academic content (O'Connor & Michaels, 1996). These revoicing functions included: Clarification, Norming, Role Casting, Highlight Common Themes, Highlight Unique Perspectives, Connect, and Relate.

Conclusion & Scientific Significance

Common Knowledge helped to engage students in scientific inquiry processes, and supported a new form of discourse within the classroom – "synchronously blended F2F discourse". Public visualizations on the classroom's IWB of the community's CK notes provided equitable access to at-a-glance formative assessment of emergent idea trajectories, and enabled the physical grouping of ideas by topic. This visualization was a common referent for topic-focused discourse, and a representation of the knowledge community's distributed cognition. These orchestration patterns imply that future iterations of CK must include an *inquiry script* informed by the 4Rs orchestration cycle, to relieve teachers of the cognitive and pedagogical dimensions of orchestration load. CK improvements should include a *collaboration script* that will further relieve teachers' cognitive load, to coordinate student grouping combinations for various stages within this inquiry script. It is our hope that these scripts will facilitate knowledge convergence within a knowledge community. On-the-fly scaffolding could be developed using real-time data mining for smarter filtering and commenting, to address emergent common themes and divergent perspectives within CK discourse. Visualization of idea-note relationships will further reduce teachers' cognitive load in their efforts to guide productive synchronously blended inquiry discourse.

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Toward a Qualitative Approach to Examining Idea Improvement in Knowledge-building Discourse

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Abstract: We report an exploratory study of discourse analysis, focusing on explaining the analytic approach. It is argued that most knowledge-building studies have taken a cognitively-oriented approach to examine collaborative discourse; therefore their findings do not shed light on how idea improvement is accomplished socially. The study employs thematic narrative analysis to address how idea improvement comes about. The paper ends with a discussion of the value of this approach.

Introduction

Among the theories of collaborative learning, knowledge building (Scardamalia & Bereiter, 2006) has unique emphases on enabling student to be in control of their own learning, progressive inquiry aimed at idea improvement, a shared goal to advance the collective state of knowledge in a community, and the use of a web-based knowledge-building environment, Knowledge Forum®. Due to these unique emphases, knowledge-building discourse is progressive, which reflects the process of how community knowledge is improved over time. van Aalst (2009) has hightlighted the importance of developing a clear account to characterize the nature of knowledge-building discourse, which can faciliate the integration of CSCL into classroom practice. In the past five years, a large scale project "Developing a Teacher Community for Classroom Innovation Through Knowledge Building" (Chan, 2011), produced numerous Knowledge Forum databases; it has provided rich resources for us to explore and characterize the nature of knowledge-building discourse.

In this paper, we present an in-progress study of discourse analysis drawing from the aforementioned project. The central problem we address is: how is an idea improved in knowledge-building discourse over time? This problem involves the issues of socio-cognitive dynamics in a community and relates to some of the fundamental questions in CSCL, such as group cognition (Stahl, 2003), and intersubjective meaning making (Suthers, 2006b). To tackle this problem, we first characterize knowledge-building discourse along a number of dimensions and then make abductive inferences to interpret variations of general patterns of interaction. Such patterns reveal sequential organization of interactions that are regarded as productive or unproductive collaboration. They are particular valuable for improving pedagogical designs of CSCL, as there are scant instances of sustained productive interactions in computer-mediated discourse (van Aalst, 2009).

Even though many prior studies on knowledge building measured the quality of idea in knowledge-building discourse, this study argues that methods used in those studies do not allow researchers to fully take into account of the fundamental assumption of knowledge building theory: collective knowledge is progressively improved in a community over time. Therefore this study takes a different approach to analyze knowledge-building discourse. Most of the knowledge-building studies that closely examined computer-mediated discourse have taken a cognitive-oriented approach. They examined the quality of discourse by following the procedures of content analysis suggested by Chi (1997), in which discourse is segmented into standardized units and then each unit is assigned to theoretically derived, mutually exclusive categories. The coding scheme is the backbone of content analysis (Titscher, Meyer, Wodak, & Vetter, 2000), and the schemes developed in those studies have revealed many important insights into the dimensions of discourse. After a comprehensive review, coding schemes were developed around three major foci: subject matter (e.g. clothing design, Lahti, Seitamaa-Hakkarainen, & Hakkarainen, 2004), theoretical framework (e.g. knowledge-building principles, Zhang, Scardamalia, Lamon, Messina, & Reeve, 2007), and cognitive performance (e.g. depth of explanation, Lee, Chan, & van Aalst, 2006). However, these coding schemes do not shed light on processes of idea improvement because of the inherent limitations in content analysis. The limitations include discarding the semantics, sequential, structural, and situational information about the process of collaboration, which have been widely acknowledged (Stahl, 2002; Suthers, 2006a).

This study takes a social-cultural approach to study collaborative discourse. In this approach, social interaction constitutes the focus of the analysis, rather than retreats to the background of analysis (Arnseth & Ludvigsen, 2006). The majority of CSCL studies taking this approach have employed conversation analysis (ten Have, 2007). For instance, they tried to track the process of convergence (Roschelle, 1992), to reveal participants' methods to call something into doubt (Koschmann et al., 2005), to uncover how a small group make use of the technological affordances of a dual-interaction space (Perit Çakır, Zemel, & Stahl, 2009), and to study the verbal and nonverbal aspects of interactional patterns in group learning (Sawyer, 2006). Conversation analysis is mainly used in synchronous, small group conversations, with special transcription conventions indicating non-verbal aspect of the interactions. However, Knowledge Forum is a text-based, asynchronous discussion platform used by a whole class of students. Conversation analysis is an inappropriate method for analyzing knowledge-building discourse. Instead, this study employs narrative analysis to configure a succession of interactions to produce explanatory stories of how idea improvement comes about.

Methodology

Research Context and Participants

The data in this study was taken from the aforementioned project. The data comprised asynchronous discourse from three Knowledge Forum views from three classrooms: Grade 5 Science (matters and power; 38 students; 346 notes), Grade 10 Visual Art (community arts; 19 students; 292 notes), and Grade 10 Liberal studies (mixed classes advanced discussion political engagement; 82 students; 126 notes). These views were created during academic year of 2010-2011. Thus we employed purposeful sampling; the selection criteria were high build-on levels and rich discussion content, as judged by the first author. The reason for such criteria was to select the views that were likely to show productive collaborative interactions.

Research Context and Participants

This study has employed narrative analysis to examine knowledge-building discourse. Narrative displays human projects as situated actions in which participants purposefully engage, and it configures a series of events and actions into goal-directed processes (Polkinghorne, 1995). The focus of narrative analysis is on agency and intention through close examination of each case (Riessman, 2008). Narrative typically involves an original state of affairs, a series of events, and the consequent state of affairs (Czarniawska, 1998). The series of events are connected chronologically and thematically by means of a plot. The plot provides the narrative structure that describes the relationships between the events and their contributions to the consequent state of affairs. There can be different types of plots to connect the events, for example how a group of students success or fail in sustaining productive interactions. The data in this study did not come in storied form. The analysis composed the data and produced them into storied form (Polkinghorne, 1995). This study strived to address the problem of how idea improvement comes about. This study has employed thematic narrative analysis (Riessman, 2008), focusing on what was said in the Knowledge Forum database. In other words, the analysis did not emphasize how the discourse was produced in the classroom conditions and the non-verbal aspect of communications.

The method comprised a two stages analysis with different levels of granularity in each stage. However, before the analysis, the computer notes needed to be pre-processed for coding, and were arranged in inquiry threads for the subsequent analysis. The first-stage analysis was a qualitative coding, in order to characterize knowledge-building discourse along a number of dimensions. The unit of coding was an *event* (an action). The second-stage analysis was narrative analysis, in order to identify meaningful patterns of interaction in relation to idea development. The unit of narrative was a collaborative episode, consisting of a series of temporal events identified in the first-stage analysis. Each of the analytic steps is explained following.

Pre-processing the Collaborative Discourse into Inquiry Threads

Knowledge Forum supports asynchronous conversation for a whole class of students and provides flexible build-on functions; therefore, the discourse flow has incoherencies. For example, a threaded discussion may contain multiple inquiry problems; a problem may be addressed across multiple threaded discussions. To circumvent this problem, notes in Knowledge Forum database were restructured into inquiry threads. Zhang et al. (2007) have defined an inquiry thread “as a series of notes that address a shared principal problem and constitute a conceptual stream in a community knowledge space” (p. 125). In other words, notes that addressed a same problem were grouped to an inquiry thread, regardless of their original thread structure. We read the note content several times to identify the major problems investigated in the views. We then grouped them together accordingly. As the inquiry threads became the context for the subsequent coding and analysis, the sequence of notes preserved the order in which the notes were created. The sequence of notes in an inquiry thread followed semantic chronological order, in which notes were placed in sequence, first according to their thread structure and second their time of creation (Wise & Chiu, 2011). Therefore, the meaning of an utterance could be interpreted within an on-going discourse, and the nuances and contextual resources used to sustain the inquiry could be traced in the inquiry threads. The notes were carefully paced in sequence with annotations, assisted by Atlas.ti (Computer Assisted Qualitative Data Analysis Software).

First-stage Analysis: Qualitative Coding

The coding process started with a theory-driven approach, and then followed by a data-driven approach. First, the 7 major discourse dimensions in van Aalst (2009) study were adapted and they were further developed theoretically. The 7 dimensions were agency, community, idea, meta-discourse, information, linking, and question. Second, the theoretical ideas and the original coding scheme in van Aalst (2009) study were used to guide the coding process assisted by Atlas.ti. The first author studied the inquiry threads one by one and focused on coding one discourse dimensions each time. She started with the most well defined dimension (idea) and ended with the least defined dimension (metadiscourse). As the coding process followed the qualitative tradition, the collaborative discourse was not standardized to fix unit of analysis. Instead, the unit of analysis was an *event*: an action or interaction. An event did not have a fix length, and it might contain a word, sentence, note, or multiple notes, depending on the meaning of an event. The guiding idea was that an event itself needed to contain enough discourse to be meaningful and understandable (Coffey & Atkinson, 1996). While events included both collective actions and individual actions, the technique of simultaneous coding was employed, which meant that events could be overlapped, nested, or embedded to one another (Saldana, 2009). This coding technique reflects the complex and intertwined nature of social interactions. To accurately describe the empirical data, new events were added to the original coding schemes, while some sub-codes in the scheme were deleted. Once there were changes in the event list, all of the data were coded again. When there were no more changes to the event list, the similarities among coded segments in an event were identified and used to develop the event descriptions. To ensure the accuracy of descriptions (credibility), the descriptions and coded segments were given to another research student for "member check". In sum, the 7 discourse dimensions were derived theoretically and 38 events were derived from the data. The events were developed based on all data in this study, rather than only a small part of it.

Second-stage Analysis: Narrative Analysis

In narrative analysis, the aim is to explain why and how something has happened by means of configuring a series of sequential events that are consequential for what happened (Polkinghorne, 1988). In this study, narrative explanation was developed to account for the cause of idea development. The cause referred to combinations and accumulations of events constituting certain patterns of social mechanisms. The unit of narrative was a collaborative episode which involved multiple chronological events that were sustained enough to show how an idea was evolved over time. One inquiry thread might contain more than one collaborative episode, depending on the thread structure. Using a collaborative episode as a unit of analysis followed the idea of group cognition, according to which knowledge building emerges from group interactions with its own methods and properties (Stahl, 2002). The narrative plots to configure the intentional and unintentional events into a coherent whole were productive and unproductive collaboration. As human actions are not entirely replicable (Polkinghorne, 1995), there was a range of variations within each plot. The focus was on synthesizing the collaborative episodes and preserving the unique characteristics of them. We first read the inquiry threads one by one to identify collaborative episodes. We then assigned each collaborative episode to one of these four groups: chat-chat, idea sharing, idea co-construction, and idea development. The episodes assigned to idea development group needed to fulfill two criteria: (1) they at least contained one explanation event; (2) the explanation event did not directly build onto the seed question of the thread. The reasons were that the thread should contain rich content knowledge, and explanation event was the best type of idea in the code list, and that the rich content should come out of collaborative interactions, rather than of an individual for answering the seed question. This stage of analysis is work in progress.

Discussion

The study has taken the social-cultural approach to examine knowledge-building discourse, which has been mainly examined by the cognitive-oriented approach. The study has employed thematic narrative analysis, consisting of two-stages: qualitative coding and narrative explanation. Even though this study does not report its findings, the analytic method allows the authors to conduct future studies. The direction of the future study is to characterize the nature of knowledge-building discourse, in order to develop account of general patterns of productive collaboration. The account is particularly valuable in pedagogical designs. As computer-mediated collaborative inquiry is widely employed in schooling, the conditions and mechanisms for productive collaboration remind unclear. The patterns of productive knowledge-building discourse can inform researchers where pedagogical supports are needed, and then they can design pedagogical supports to scaffold students toward productive collaborative inquiry (Chan, 2011). And such patterns can also be taught to students as criteria of formative assessment to monitor their process of collaborative inquiry (van Aalst & Chan, 2007). Students are the agents in deciding how to react or respond as the inquiry unfolds; however, they may not be aware of the collective nature of inquiry process as a whole. Students often only are aware of the quality of the message they write, without being aware of where the line of inquiry is going. Thus, it is important to engage students in formative assessment, so that they can continuously step back, assess, and reflect on the messages they contributed to their community. The assessment criteria can help students to reflect on how their messages affect the subsequent interactions and to decide what they should do in order to engage in knowledge creation. This formative assessment is a promising tool to foster student metacognitive abilities.

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Group Work in the Science Classroom: How Gender Composition May Affect Individual Performance

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Abstract: Current research on how gender composition within groups influences individual outcomes is both sparse and conflicting. We examined how gender composition within groups affects learning outcomes. Students from sixth, seventh, and eighth grade classes from three US Midwestern public school districts with diverse demographic compositions (N=637, 314 boys and 323 girls) participated in this study as a part of their regular science class during a 12-week design-based physics curriculum, CoMPASS. We conducted two 5 x 2 analyses of covariance to evaluate the effect of group gender ratio and gender on students' physics learning and science practice outcomes. Results indicate that group gender ratio does influence students' science learning and practices as measured by posttest differences. Students in mixed-gender groups performed significantly better than students in same-gender groups. Having at least one group member of the opposite gender increased individual students' posttest performance. Limitations and implications for practice are discussed.

Engaging students in group work during inquiry-based and project-based learning activities has become an increasingly common practice in science classrooms. However, as research suggests, students may not always effectively collaborate in ways that foster learning (Barron, 2003; Rummel & Spada, 2005). Further, collaborative learning may not always result in equivalent learning gains for each individual (Teasley & Fischer, 2008; Gnesdilow, Bopardikar, Sullivan, & Puntambekar, 2010). Several factors such as group size, context, gender, prior knowledge, and individual abilities may affect the collaboration in groups (e.g., Apedoe, Ellefson, & Schunn, 2012, Hawkins & Power, 1999).

In this paper we focus on understanding how the gender composition in groups affects students' learning outcomes in science. The current research on how gender composition in groups influences individual outcomes is both sparse and conflicting. Ding, Bosker, and Harskamp (2011) discussed that while Computer Supported Collaborative Learning (CSCL) has the potential to lessen the gender gap between male and female performance and persistence in physics, the positive findings from CSCL research "are controversial where gender is concerned" (p.325). Leman (2010) pointed out that there is a scarcity of empirical research linking "interactions and collaboration to gender and learning outcomes" (p.218). Research has indicated that there are differences between how boys and girls learn, converse, and interact (Leman, 2010; Kommer, 2006; Rice & Dolgin, 2002), including when within mixed-gender groups (Hawkins & Power, 1999) and also within mixed-gender dyads (Ding, Bosker, & Harskamp, 2011; Harskamp, Ding, & Suhre, 2012). Some studies have found that girls in mixed-gender groups do not perform as well as girls in same-gender groups (e.g. Light, Littleton, Bale, Joyner & Messer, 2000). Similarly, other studies have revealed that high school girls learning physics in mixed-dyads scored significantly lower on posttests than the boys working in the mixed-dyads, as well as the boys and girls who worked in same-sex dyads (Ding et al., 2011; Harskamp et al., 2012). Alternatively, one of the key findings highlighted by Bennett, Hogarth, Lubben, Campbell, and Robinson's (2010) review of studies of small groups in science classrooms was that students in single-sex groups were more purposeful than mixed-gender groups, but ultimately group gender composition did not affect understanding. In another study, girls participated more actively and persistently on collaborative learning activities when in mixed-gender groups, including generating more science and group orchestration talk during computer-based learning activities (Goldstein & Puntambekar, 2004).

Given the contradictions between the findings outlined above, as well as the lack of overall evidence about how gender composition affects students' learning in groups, we believe that understanding these relationships could lead to strategic and easy-to-implement teaching decisions for enhancing collaboration and learning. In this study we examined how gender composition in groups affects students' learning outcomes and attempt to answer the research question: Do differences in gender composition affect middle school science students' learning in groups? We explored this question by examining students' science content knowledge and practices outcomes.

Methods

Participants and Instructional Context

Two hundred sixth grade, 143 seventh grade, and 294 eighth grade students (N=637, 314 boys and 323 girls) from three US Midwestern public school districts with diverse demographic compositions participated in this study as a part of their regular science class. All students took part in the CoMPASS roller coaster unit, a 12-week design-based science curriculum, to learn about forces, motion, work, and energy. They participated in a variety of physical science activities in order to design a fun, safe, and efficient roller coaster for an amusement park whose attendance is waning. Students worked in the same group of three of four throughout the 12-week unit (Group N=178, 54 sixth, 41 seventh, and 83 eighth grade groups), with group composition determined prior to this study by our collaborating teachers. Students took separate pre- and posttests for science content and practices (described below). Students took these tests before starting and after finishing the CoMPASS roller coaster curriculum in their classes.

Data Sources and Analysis

Measures

We used two tests: the Physics Fiesta measured students' content knowledge in physics and the Scientist's IQ tested science practices. The Physics Fiesta consisted of 29 multiple-choice questions and addressed a range of physics concepts and relationships such as mass, work, force, potential and kinetic energy, velocity, acceleration, efficiency, the law of conservation of energy, and Newton's Laws. Each correct item earned a score of one point and incorrect answers were scored as zero, with 29 points being the highest score possible. The Scientist's IQ consisted of 13 multiple-choice and five open-ended questions that assessed students' skills in areas such as interpreting, making inferences, setting up data in graphs and charts, hypothesis writing, variable identification in setting up experiments, using data to back up reasoning and explanations, and identifying measurement and other sources of error in investigational scenarios. Correct multiple-choice responses on the Scientist's IQ earned one point and incorrect responses were scored as zero. The open-ended questions were graded from 0 to 2 or 3 points. A score of 2 (or 3) indicated a more sophisticated, elaborate response or explanation, while a zero indicated that the answer was incorrect, blank, or unintelligible. Answers coded as 1 or 2 points (for 3-point questions) were correct but not explained well, supported, or were partial responses. The maximum score for the Scientist's IQ was 24 points. Interrater reliability for scoring the open-ended responses on the Scientist's IQ pretest was 94.35% and 92.5% for the posttest.

Gender Ratio Group Categories

To examine how the gender composition of groups influenced each student's learning outcome, we used five different Gender Ratio categories. The five categories were: 1) all boys, 2) mostly boys (i.e. 2 or 3 boys in a group of 3 or 4, respectively), 3) even split between boys and girls, 4) mostly girls (i.e. 2 or 3 girls in a group of 3 or 4, respectively), and 5) all girls. Based on the gender composition of the group that a student worked in throughout the CoMPASS curriculum, he or she was labeled as belonging in one of the five categories. For example, if a group consisted of two girls and one boy, each of the three students was labeled as belonging to a mostly girl group. Due to missing data, a total of 574 students (280 boys and 294 girls) completed both pre- and posttests for the Physics Fiesta and 530 students (259 boys and 271 girls) completed both pre- and posttests for the Scientist's IQ. Only the scores of students who completed both pre- and posttests for a given measure were included in our analysis.

Results

We conducted two 5 x 2 analyses of covariance (ANCOVA) to evaluate the effects of group Gender Ratio and Gender on students' scores on the Physics Fiesta and Scientist's IQ tests. The independent variable, Gender Ratio, included five levels: all boys, mostly boys, even split, mostly girls, and all girls. The other independent variable was Gender. The dependent variables were the Physics Fiesta posttest score and the Scientist's IQ posttest score. To meet the assumptions of ANCOVA, we established that the Physics Fiesta pretest score was significantly related to the posttest score, $F\ (1, 565) = 155.014$, $p < .001$ and the Scientist's IQ pretest score was significantly related to the posttest score, $F\ (1, 521) = 895.880$, $p < .001$. Thus, the relationship between the covariates and their respective dependent variables did not differ as a function of the independent variables.

Table 1 displays the descriptive statistics of each posttest. ANCOVA results showed there was no main effect for Gender, a significant main effect for Gender Ratio, and no interaction. The ANCOVA indicated no significant difference in posttest performance of boys and girls on the Physics Fiesta posttest after controlling for pretest score, $F\ (1, 565) = .561$, $p = .454$. Comparably, there was no significant difference between boys and girls in the Scientist's IQ posttest after controlling for pretest score, $F\ (1, 521) = .154$, $p = .695$. When comparing differences in mixed-gender and same-gender groups, it was important to find that gender alone was not a significant predictor in posttest performance. Boys did not perform significantly better than girls and therefore skew group means. Since there was no effect of Gender, we know that the effect of Gender Ratio on posttest scores cannot be attributed to performance based on a specific gender.

The ANCOVA further indicated that there was no interaction between Gender and Gender Ratio on the Physics Fiesta posttest score when accounting for pretest score, F (2, 565) = .304, p = .738. Controlling for pretest score, there was also no interaction between Gender and Gender Ratio on the Scientist's IQ posttest score, F (2, 521) = .454, p = .635. Results showing no interaction for either test suggest that Gender did not change posttest score based on group composition and indicates that posttest score effects are based solely on Gender Ratio. Because there was no effect of Gender or interaction between Gender and Gender Ratio over three different grades and three different school districts, our results support the idea that group composition is a more important determinant of posttest score and that this result does not vary based on the student's gender.

Gender Ratio

There was a significant effect of Gender Ratio on the Physics Fiesta posttest after controlling for the effect of Physics Fiesta pretest score, F (4, 565) = 3.024, p = .017. The students in the mostly girl groups had the largest adjusted mean (M = 17.431), and students in the even split groups had the next largest adjusted mean (M = 17.238), followed by the third largest adjusted mean in mostly boy groups of students (M = 16.960). The two lowest adjusted means were observed in students in all boy (M = 16.220) and all girl groups (M = 15.854).

There was also a significant effect of Gender Ratio on the Scientist's IQ posttest after controlling for the pretest, F (4, 521) = 2.680, p = .031. Similar to the Physics Fiesta test, the mostly girl groups of students had the largest adjusted mean score (M = 15.140), followed by students in mostly boy groups (M = 14.942) and then students in even split groups (M = 14.920). The groups of students with all girls (M = 14.592) and groups of students with all boys (M = 13.436) had the lowest adjusted means on the posttest. The Gender Ratio main effect indicated that the mixed-gender groups of mostly girls, even split of boys and girls, and mostly boy groups tended to have higher posttest scores than the same-gender groups that had all girl or all boy students.

Table 1: Descriptive Statistics for posttest score by Gender Ratio

		Posttest score			
Posttest	Gender Ratio	Observed Mean	Adjusted Mean	*SE*	*n*
Physics Fiesta	All Boys	16.03	16.220	.452	73
	Mostly Boys	16.87	16.960	.414	104
	Even Split	17.61	17.238	.268	211
	Mostly Girls	17.63	17.431	.412	106
	All Girls	15.03	15.854	.437	80
Scientist's IQ	All Boys	12.14	13.436	.426	70
	Mostly Boys	14.03	14.942	.400	91
	Even Split	15.89	14.920	.258	192
	Mostly Girls	15.37	15.140	.383	105
	All Girls	13.97	14.592	.418	72

Post Hoc Analysis

In order to explore the posttest differences based on Gender Ratio, we conducted contrasts to observe any potential differences between mixed-gender and same-gender group composition. To do this, we grouped the means of all of the heterogeneous gender groups (mostly girl, even split, and mostly boy groups) into a mixed-gender category. Then, we combined the means of the all girl and all boy groups together into a same-gender category. Contrasts revealed that Physics Fiesta posttest scores for students in mixed-gender groups were significantly higher than for students in same-gender groups, $p < .01$. Likewise, mixed-gender groups of students had higher Scientist's IQ posttest scores than same-gender groups of students, $p < .01$.

Discussion

In attempting to answer our research question, our analysis supports the idea that group gender composition does influence students' science learning and practices as measured by the Physics Fiesta and Scientist's IQ, respectively. We found that students in mixed-gender groups outperformed students in same-gender groups on both the content and practices posttests, when controlling for pretest score. No difference at the gender level may indicate that students' individual success may be better explained by gender composition within a group. Our results contrast with Light et al.'s (2000) finding that females perform better in same-gender versus mixed-gender groups. And, while group size may be a confounding factor in making clear-cut comparisons between studies, our results also seem to conflict with studies that show that girls in mixed-gender dyads scored lower than their boy counterparts on physics posttests (Ding et al., 2011; Harskamp et al., 2012). In addition, we found that students in mixed-gender groups with at least two girls performed slightly better than students in other groups, and that students in same-gender groups were less successful. From these results, one might think that collaborative work within this science context may favor the skillset of female students. However, if girls are the key, then students in all girl groups should outperform students in other groups, but this was not the case. Presence of at least one member of the opposite gender increased individual students' posttest performance in both science content and practices. These are nuanced dynamics; therefore, we will need to qualitatively examine the discourse of students in groups of different gender compositions to better understand and elaborate on how these outcomes may have occurred.

Gender is an important factor in collaboration (Leman, 2010), and Kommer (2006) stressed that it is important for teachers to understand how to organize groups to optimize students' strengths. The gender composition of groups may be a key factor and certain ratios may prove to be more beneficial than others to foster students' learning and collaboration. While we had a large number of students, one limitation of this study is that it does not include process data to help explain why these findings may have occurred. There are other factors that could result in differences in students' performance, such as the influence of different classroom contexts, teacher variables, grades, or districts. It will be important to explore these factors in future studies, as well as use group process data, to understand what is qualitatively different in the interactions of successful mixed-gender groups so that these findings may be applied to all groups in a classroom, no matter the gender composition. In combination with our future work on analyzing groups' discourse, our findings may inform teaching decisions about how to structure CSCL group composition in practical and simple ways.

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The Influence of Training in Argumentation on Students' Individual Learning Outcomes

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Abstract: We conducted an in vivo experiment (Aleven & Koedinger, 2002) to investigate the impact of *Adventures in Argument*, a week-long online unit in argumentation, on subsequent science learning from an online course in which individual and collaborative argumentation were the primary forms of pedagogy. The context of the study was HAL Online, an undergraduate course in The Learning Sciences that enrolled 44 students. Using a nested design (students within groups within treatment), the treatment condition, Trained Argumentation with Modest Scaffolding (TAMS) was compared with an ecological control group: Emergent Argumentation with Modest Scaffolding (EAMS). Results of quantitative analyses indicated that TAMS was an effective intervention that positively influenced students' individual learning as measured by a test of scientific literacy and scores from coding of individual reflective blogs. Direct training in argumentation offers a viable, pragmatic supplement or alternative to immersive collaborative pedagogies that require guidance and scaffolding of students' online argumentation processes by faculty (Cavagnetto, 2010).

Introduction

We have embraced collaborative and individual argumentation as the primary pedagogical strategies for Human Abilities and Learning Online (HAL Online), an undergraduate course in The Learning Sciences designed for educators. The benefit of argumentation as pedagogy has been recognized for its potential to improve science knowledge and promote scientific literacy (e.g. Cavagnetto, 2010; Driver, Newtown & Osborne, 2000). A belief common among science educators is that immersing students in the collaborative process of science, where argumentation is implicitly embedded in this process, is the optimal way to promote scientific literacy (Cavagnetto, 2010). One drawback to this approach, however, is that it is extremely time-consuming, requiring students to be immersed for long periods in the scientific process. Moreover, as research indicates (e.g. Glassner & Schwarz, 2005; Kuhn, 2005), argument quality is generally poor among students across levels. Therefore, teachers and curriculum designers have significant responsibility for scaffolding and guiding argumentative discourse. This may be impossible to accomplish effectively through an immersive approach in large classrooms where teachers are overloaded, restricted by time, and may in some cases have weak argumentation skills themselves. In our university setting, where there is constant pressure to increase enrollments despite lower instructional budgets, scaffolding and guidance may be provided online to many students by a single faculty member unassisted, or with the help of relatively inexperienced teaching assistants. We therefore needed to investigate viable, pragmatic alternatives to guided argumentation during immersion. One option is designing instruction that formally trains students in argument structure *prior* to introducing domain content through pedagogies that engage learners in activities requiring evaluation and use of science concepts as evidence for claims and that hold them responsible for well-reasoned thinking.

The purpose of this study was to investigate the effectiveness of a week-long argumentation lesson on subsequent student learning of science and the development of scientific literacy. The performance of a group receiving the treatment lesson, designated the *Trained Argumentation with Modest Scaffolding* (TAMS) group, was compared with an ecological control group that did not receive the training: *Emergent Argumentation with Modest Scaffolding* (EAMS). Following the treatment manipulation, both groups participated in an identical four-week unit which focused on cognitive and neuroscience concepts. Analysis of student performance data from this unit addressed a range of research questions related to outcomes and discourse processes. Here, we will focus primarily on results related to the following questions: Q1. Based on a post-unit measure of scientific literacy, does TAMS, compared to EAMS, promote better science learning from instruction that engages students in scientific discourse? Q2. Relative to EAMS, does TAMS increase the spontaneous tendency to use and make connections among scientific course concepts during subsequent course-related tasks and discussions, likely indicating more sophisticated processing of the material?

Theoretical Basis for TAMS

Toulmin's model (1958), the Toulmin Argument Pattern (TAP) has served as the basis for many educational approaches using argumentation (e.g. Kuhn, 1991; Leitao 2000; Stegmann, Weinberger & Fischer, 2007). The

TAP focuses on six core elements of arguments. Toulmin's model is the basis of Halpern's (2003) *Analyzing Arguments*, a chapter in her award-winning text *Thought and Knowledge*. This chapter was used as the basis of argument training in this study. After introducing the TAP, Toulmin (1972) introduced the idea of argumentation fields, the idea (briefly stated) that argument components and qualities are not universally generalizable but must be reflectively adapted to contexts. Thus Toulmin's perspective denotes a 'sweet spot' between absolutism and relativism that is useful in framing instructional approaches in which a general argument model can be adapted to different problem contexts. Kuhn (2005) also recognized the importance of meaningful context with emphasis on teaching general argument skills in a way that can be transferred to new situations. Our TAMS treatment, a lesson entitled *Adventures in Argument*, was inspired by these views.

Data Source and Design

This study used an *in vivo* experimental design (e.g. Aleven & Koedinger 2002). The context of the study was the spring, 2011 online section of Human Abilities and Learning (HAL Online) at a large Midwestern university, an undergraduate course that enrolled 44 future educators from various fields. Undergraduates in this course read about sophisticated science concepts from cognitive and neuroscience research, and were expected to gain understanding of and practice with integrating these ideas to support decision making in individual and group problem-based learning activities. The course was divided into four units comprised of four or five week-long lessons each. During a lesson, students read and accessed multimedia resources while completing weekly activities that involved problem solving and higher-order thinking with the learning-science material, and that incorporated embedded assessments. Every other week the assessment activity required students to write an individual reflective blog. In alternate weeks, the assessed activity involved small group discussions online. The treatment manipulation was the last lesson in the first course unit. The course was offered in the Moodle course management system. A separate Moodle course environment was created for each condition. These were identical except for the treatment-related manipulations, described next.

Treatment: Training in Argumentation with Modest Scaffolding (TAMS)

The TAMS treatment involved students in a course of formal training in argumentation based on the hypothesis that the training would improve thinking and lead to more meaningful learning. During the lesson students read "Analyzing Arguments," a substantial chapter on argumentation from the text *Thought and Knowledge* (Halpern, 2003). After reading, students completed an individual quiz and participated in collaborative forum discussion that involved evaluating an argument. The quiz assessed student understanding of key concepts in the text, including the ability to analyze a written argument. To complete the discussion task, students watched a TED video of Patrick Awuah (2007) describing a program of liberal arts education offered at Ashesi University and arguing that this program was developing African leadership. Small groups then collaborated to evaluate the observed speaker's argument.

Ecological control: Emergent Argumentation with Modest Scaffolding (EAMS)

In the EAMS control group students received an alternative week-long lesson that did not focus on argument training, but rather on a scientific model of hypothesis testing. During this lesson students read an alternate chapter of comparable length and complexity from *Thought and Knowledge*, "Thinking as Hypothesis Testing." This topic was selected for the control condition because it represents a widely accepted alternative scientific model for good thinking that is widely taught but does not emphasize argument structure or process. During EAMS students also completed a quiz and participated in a collaborative forum discussion. In the forum discussion, students watched the same TED video of Patrick Awuah (2007) seen by students in TAMS and collaborated to design a study that would evaluate the speaker's causal hypothesis.

Participants

Using a within classroom design (Salden & Koedinger, 2009), students who enrolled in HAL Online were assigned to small groups based on common interests as determined by self-report surveys. Small groups were randomly assigned to the two conditions. Groups comprised three or four students and, to avoid confounding the group dynamic, students worked in the same groups throughout the course.

Method of Analysis

We used a mixed quantitative and qualitative approach (e.g. Barron, 2003). Statistical analysis followed procedures for nested designs recommended by Kirk (2012), where individual students were nested in small groups, which were compared across conditions. Qualitative analysis followed procedures for quantifying qualitative data recommended by Chi (1997).

The analysis related to the first research question was based on scores from a scientific literacy post-test, a written essay requiring students to respond to (supporting or challenging) a statement about the role of the study of brain research in college curricula for future educators. Post-tests were scored by a panel of three paid experts in scientific literacy who were blind to condition and were trained to use a scoring rubric. The rubric was developed using the definition of scientific literacy given by the National Science Education Standards, which is based on historically agreed-upon principles of what it means to be scientifically literate. Rubric criteria subjects were scored on included: demonstrates understanding of science constructs in the article; accurately uses science to support claims; takes credibility of sources into account; and recognizes multiple positions on the issue. The scoring reliability based on Fleiss' kappa was .89 on a sample of 10 post-tests. Scores for TAMS and EAMS were compared using a nested ANOVA design. An identically scored baseline measure of scientific literacy and concept use, collected from embedded assessments for a course lesson prior to the experimental/control lessons, provided a covariate.

We addressed the second research question using Chi's verbal analysis method (Chi, 1997) to score an individual reflective blog assignment in which students spontaneously used any course concepts they chose to explain what they learned from a lesson. In this analysis we asked how many concepts students used from course readings and how they integrated these concepts in their blog posts. The specific adaptation of Chi's method included searching the data, coding the data for seven pre-defined target concepts about Lifelong Learning & Expertise (synaptogenesis; brain region growth with use; regional compensation; expert cognitive structures; genetics and environment interaction; emotion/motivation; and practice ["use it or lose it"]), representing the data as simplified semantic webs, and seeking and interpreting patterns. Based on semantic webs, the number of concepts and a score representing the interconnection rate among concepts ($n(n-1)/2$, where n = number of concepts used) were tabulated. Reliability of 95% (Cohen's kappa .91) was reached between coders after a single round of coding based on a sample of 10 blogs. Remaining data were coded by the first author of this paper. A semantic web was created from each student's blog, with reliability of 89% reached between coders after one round of discussion. Based on these scores, a nested ANOVA was conducted for number of concepts and connection rate.

Results and Discussion

The results of this study indicate that TAMS was an effective intervention that enhanced students' subsequent learning of science content as measured by a test of scientific literacy and assessments of students' understanding of target science concepts revealed in individual reflective blogs.

Q1: Scientific Literacy

A between subjects analysis of variance (condition (TAMS, EAMS); group (1-12); covariate: baseline) indicated the effect of treatment on a test of scientific literacy was significant. There was a main effect for condition: $F(1, 10.478) = 13.125$, $p = .002$. This means students in the treatment, TAMS ($M = 9.898$, $SE = .531$, 95% CI [8.709, 11.088]), had a significantly higher mean scientific literacy score than students in EAMS ($M = 7.111$, $SE = .556$, 95% CI [5.891, 8.331]), as measured using the rubric criteria described above. The interaction of condition and pre-score was non-significant, which indicates the treatment effect did not depend on the baseline score.

This finding suggests that, for advanced undergraduate learners in a learning sciences course, a week-long formal training lesson in argument structure and quality prior to engaging with science learning was an effective approach that promoted scientifically literate written essay responses from students. This finding extends the work of Veerman, Andriessen & Kanselaar (2002) showing that argument prompts at the beginning of a lesson promote more sophisticated understanding during content-based arguments. Moreover, this finding adds to the limited body of existing research of how training in argumentation prior to participating in science-based activities can promote scientific literacy (e.g. Osborne, Erduran, & Simon, 2004).

Q2: Understanding of Science Concepts

A between subjects analysis of variance based on individual student blog data (treatment (TAMS, EAMS); group (1-12); covariate: pre-treatment score) indicated a statistically significant main effect of treatment on connection rate $F(1, 9.764) = 3.239$, $p= .04$. The main effect of the condition for the number of concepts used by subjects, however, was not significant $F(1, 10.302) = 1.596$, $p= .107$. This means that students in the treatment, TAMS ($M = .862$, $SE = .062$, 95% CI [.722, 1.001]) demonstrated a significantly higher connection rate than students in EAMS ($M = .701$, $SE = .064$, 95% CI [.560, .843]). However, TAMS students did not use significantly more concepts ($M= 4.062$, $SE = .220$, 95% CI [3.617, 4.506]) than students in EAMS ($M = 3.667$, $SE = .229$, 95% CI [3.203, 4.130]). For both analyses, the interaction of condition and pre-score were non-significant, which indicates the treatment effect does not depend on the baseline score.

The relatively high connection levels for TAMS suggests that treatment students integrated ideas in their explanations rather than talking about them in a disconnected way. We speculated that higher rates of connection among concepts may indicate that TAMS students engaged in more evidence gathering, synthesis, and transformation – all processes of higher-order thinking required to participate in online discourse around complex educational problems that are better understood through conceptual lenses from the learning sciences.

This speculation has been partially confirmed by further qualitative analyses of group interactions that are not reported here due to space limitations.

Scholarly Significance and Conclusion

Results indicate that TAMS was an effective intervention that influenced online student learning in positive ways. This suggests that direct argumentation training designed to fall within Toulmin's (1972) 'sweet spot' between generalizability and context can promote scientific literacy and deeper understanding in online course environments. This study thus contributes to our "cognitive roadmap" of the types of skills that should be developed to improve argument-based science pedagogy online (Kuhn, 2005, p. 116). Moreover, this study sheds light on an issue raised in a recent review of argumentation interventions in science classroom activities (Cavagnetto, 2010). Cavagnetto asserts that argumentation skills are best developed through immersive engagement with science. He recognizes, however, the need for systematically investigating efficient alternative approaches. The current study demonstrates that, at least for undergraduate learners in online discussion environments, a skill-based training approach has strong potential to improve subsequent meaningful learning of psychological science, promoting scientific literacy while addressing practical concerns of efficiency. Online argument training might be especially useful in relatively unsupervised massive open online courses (**MOOCs**), a recent development in distance education aimed at large-scale participation and open access via the web.

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The MOOC as Distributed Intelligence: Dimensions of a Framework & Evaluation of MOOCs

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Abstract: Massively Open Online Courses (MOOCs) have been at the center of media attention and hyperbole since 2012. As MOOCs proliferate and continue to influence higher education, it is increasingly pressing to define frameworks for their design and evaluation. This paper proposes such a framework, grounded in CSCL and learning sciences research along with a discussion of the unique aspects of MOOCs as learning environments. Through the lens of distributed intelligence the framework defines distinct, but interconnected, dimensions of MOOCs that must work synergistically to maximize individual as well as collective learning.

Introduction and Motivation

In all the hyperbole surrounding the rollout of Massively Online Open Courses (MOOCs) over the past year and a half, much has been said and written about the "campus tsunami" (Brooks, 2012) that is purportedly poised to change the face of higher education. Interestingly, while much of the positive feedback has focused on the noble sentiments behind making world-class courses (mostly from elite universities) freely available to anyone, anywhere in the world, a fair amount of the negative press aimed specifically at instructionist MOOCs or xMOOCs (as characterized by Daniel, 2012) has revolved around the quality of the courses themselves. Though this criticism covers the gamut of instructional design issues, (mostly misplaced views of) dropout and completion rates have garnered the most attention. We believe that often both the praise and criticism of MOOCs is founded on historical assumptions about learning environments and outcomes that do not necessarily apply (at least without some reconsideration and reframing) to this new phenomenon. MOOCs today are a moving target—their form and function is shifting weekly, as course designers and platform providers around the world dream up new approaches to open online learning. To remain grounded in this shifting landscape, we need a flexible and generalizable framework for understanding the effects of MOOC design decisions on learning.

As a start, we reframe the question *What makes a good MOOC?* to *How can we make a MOOC work for as many of its diverse participants as possible?* MOOCs attract a global set of learners with an extensive range of goals and prior knowledge. These individuals vary in the approaches they take to learning, their responses to the social and pedagogical context for learning, and their intrapersonal strategies for dealing with challenges. Framing design and evaluation in this way emphasizes the potential for optimization for different participants or groups of participants—and the possibility of defining different learning outcomes for these different groups of learners. Learning outcomes should also be defined expansively, based on the goals that course designers have to influence cognitive and affective competencies of any subset of learners, or learning on the level of the collective.

Furthermore, it helps to view a MOOC as a *designed object* (Simon, 1969) whose creation should ideally be influenced not only by faculty and instructional designers, but also by technologists, data scientists and learning researchers. These stakeholders influence different elements of the MOOC that interrelate to create learning opportunities for participants. A framework for the design and evaluation of MOOCs must reflect the complex nature of these interrelationships. It must also encapsulate principles from the learning sciences to guide the creation of a robust set of criteria for the design and evaluation of MOOC learning experiences. These criteria will not only help meaningfully frame the discourse on MOOC quality, but also serve prospective learners, course designers and faculty, researchers, as well as the technologists who are charged with developing and evolving the platforms on which MOOCs are deployed to meet needs and enable innovative experimentation.

Theoretical and Conceptual Framework

Our proposed framework includes a focus on the elements that make MOOCs distinct from previous forms of *virtual learning environments* (e.g., Barab, Kling & Gray, 2004; Dillenbourg, Schneider & Synteta, 2002; Pea, 1998, 2004; Weiss, Nolan & Trifonas, 2006). We take as given the principles of learning and instructional design established by decades of work on socio-constructivist learning in CSCL and distance learning/e-learning (e.g., Harasim, 2011; Sawyer, 2005; Stahl 2004, 2006;), though identifying the best strategies for implementing these principles in the platform features and instructional strategies of MOOCs is a ripe area for future work.

There is no doubt that it is the "M" in MOOCs that underlies and influences the unique nature of the design space. Enabled by being open and online, the massive population of students with varied goals enrolled from various corners of the world requires a reconsideration of instruction and assessment strategies, as well as the possible forms of social interaction. This atypicality also underscores the need for fresh perspectives for design and evaluation that are suited to these learning environments. Moreover, the volume and nature of the data gathered for learning analytics is also on a scale and granularity that could shape learning experiences in hitherto unimaginable ways.

We argue that it is the *distributed nature of intelligence* (Pea, 1993) and the associated learning experiences that is heightened most in MOOCs. Pea's argument that the resources that shape and enable learning and learner activity "are distributed in configuration across people, environments, and situations" is actualized, even amplified, in MOOC settings, where the designed learning environment embodies the pedagogical assumptions of the technologists and instructors. Additionally, in keeping with Pea's distributed intelligence framework, MOOCs also exemplify both the social as well as the material dimensions of distributed intelligence. Many of the traditional roles and responsibilities of the teaching team are distributed among learners because of the scale of the MOOC. For example, learners push each other's understanding through participation in the discussion forum, and assess one another's work in instances where human feedback is preferable to automatic grading. Learning in a MOOC is also shaped in unconventional ways by the artifacts and affordances of new technology tools such as those that support educational data mining, crowd-sourcing, as well as social and cognitive *presence* (Garrison, 2007) in the learning environment.

Dimensions of a MOOC Design and Evaluation Framework

As suggested in Figure 1, our framework for design and evaluation envisions a MOOC as four distinct dimensions across which intelligence is distributed. While the interactive learning environment is at the core of the learning experience, learning by individual participants and of the group as a whole results from a synergistic interplay between each of these dimensions. Faculty, instructional designers, technologists, data scientists, and learning scientists together bring the expertise to shape the environment for optimal learning. Our framework also serves to guide these conversations.

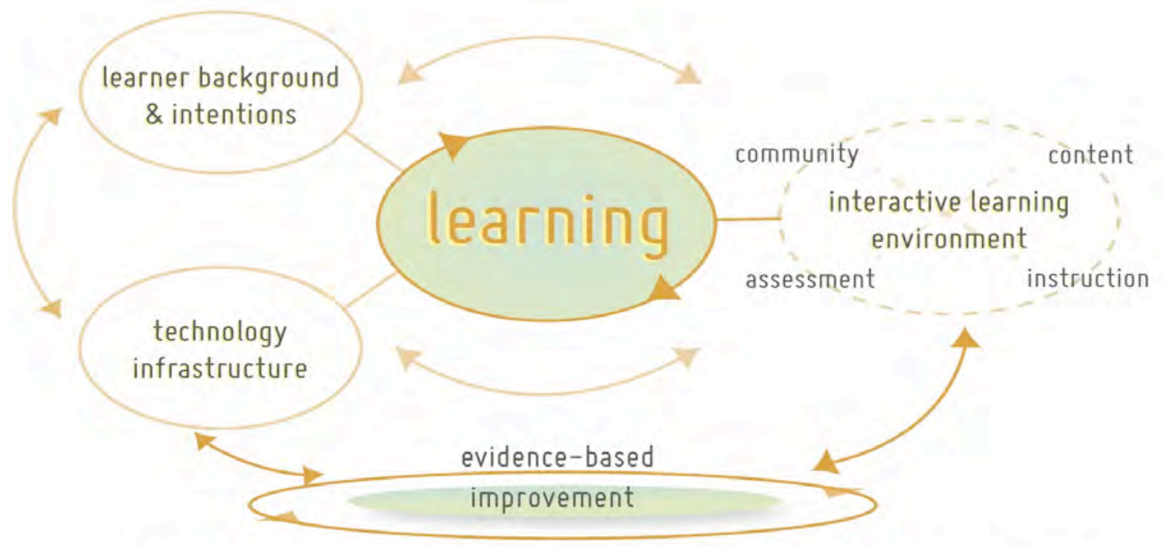

Figure 1. Framework for the design & evaluation of MOOCs

The *Interactive Learning Environment (ILE)* is made up of the core course elements — *Content*, *Instruction* (or Pedagogy), *Assessment* and *Community*. These elements are initially shaped by the course creators as well as the technical affordances of the course platform. These design choices reflect the assumptions of designers about the ways in which people learn, and should be pushed to reflect the state of the art of knowledge in the learning sciences. For example, many current MOOCs rely on a lecture-style "talking head" delivery mode of content, which presupposes a transmission and acquisition model of education (Rogoff, 1990), rather than supporting alternate learning approaches where learners might instead be tasked with generating their own knowledge, and participating in extra-MOOC, offline learning and reflection experiences as part of their required activities. As the course goes on, learners choose how they interact with these elements of the ILE to fashion an experience to suit their needs. This is manifested most powerfully in the context of the *Community* element, as learners control their relationship with other learners and the MOOC instructor through their interactions with them, both face-to-face in meet-ups, and online using beyond-MOOC groupware such as Google+. These choices about interaction and assessment are also driven by the learner's background and intentions, as described below, or in some cases, by other faculty who may be using the MOOC in a blended or flipped mode in their classrooms. The MOOC designer is charged with enabling and enhancing these experiences in a way that best serves the unique needs of individual learners—for example, a MOOC tailored to a college student taking the course for credit in a formal setting or in his/her individual capacity would involve various forms of formative and summative assessment, requirements for participation, and course expectations that would not suit the needs of the casual middle-aged learner taking the course out of curiosity in the subject.

Learner background and intention captures the variety of learner purposes for course engagement, which is a byproduct of the open access nature of the courses and the novelty of the medium. Based on surveys we have conducted in some MOOCs, in addition to traditional students taking the course for some form of credit, a large percentage of others are enrolled with purposes as assorted as "curiosity about the topic", "to sharpen my job skills", and "fun and challenge." This pattern implies a need to serve up different courses suited to the varied purposes of MOOC learners: a customized learning approach that could be enabled by analytics on behavioral data from learners, as well as self-reported intentions for MOOC enrollment. This also means that traditional measures of learning outcomes like course completion may not accurately reflect MOOC student engagement.

The *technology infrastructure* comprising the MOOC platform used in conjunction with social media and other technology tools for augmenting communication and interaction powers the MOOC as a whole including its learning analytics engine, and serves to cater to diverse learner needs ranging from geography and language to issues of how the MOOC content is accessed and interacted with (e.g., downloading vs. streaming video). Crucial design decisions include how to leverage technology affordances for achieving the learning objectives of MOOC participants and how data about learners and learner interactions are collected and analyzed to support (even real-time) improvement of both the underlying platform technology and the learning environment.

Finally, *evidence-based improvement* is a meta-MOOC process undergirding design decisions around the ILE and technology infrastructure. Evidence-based improvement is powered by data mining and analytics designed to measure the desired course learning outcomes, and incorporates qualitative evidence from sources like forums and surveys. Evidence-based improvement is important to any learning environment, but it deserves particular attention in MOOC design and evaluation as it provides an opportunity for leveraging the distributed intelligence of the many MOOC stakeholders to create a virtuous iteration cycle leading to improved learning.

Leveraging the affordances and intelligence in each of these dimensions will result in a MOOC that strives to work for as many of its diverse learners as possible. In such a MOOC, each dimension interacts meaningfully with every other dimension. Within the limits of this short paper, we highlight one example of the interplay between dimensions, indicating how it influences design and evaluation decisions. An instructor offering a mathematics MOOC may want to use the creation and evaluation of proofs as a key assessment piece. However, because there is no reliable way to machine grade proofs, the instructor decides to leverage the distributed intelligence and learning of the students in the course in a peer assessment system. The technology platform supports this process through a peer assessment module. After a first round of peer assessments, the instructor realizes through analytics and forum posts that students need more support grading one another's work, and so records a new video modeling the grading process, and incorporates grading exercises into the weekly assessments. In this example the instructor leverages all parts of the learning environment: community grading of peers' content knowledge, as well as assessment and instruction as a scaffold for peer grading. The instructor leverages the technology infrastructure to make changes, and responds to student backgrounds by providing multiple avenues for learning to peer grade. Finally, the instructor makes a meaningful improvement based on data from analytics and forums. Note that instructor responsiveness is itself a design decision, and the improvements made *in situ* in this example could have been designed to be driven by analytics and peer assessment algorithms and put in place prior to the start of the course.

Thus we see that this framework essentially means pushing downward in the pyramid from faculty to students the responsibilities for *collective learning* (Pea, 1994) of the MOOC participants as a whole, and design for innovative and hitherto untested technology infrastructure elements such as scaffolding social learning group formation, peer assessment, question-clustering techniques, polling/voting up mechanisms, or karma points (Lewin, 2012) for incentivizing initiative in supporting others' learning in the MOOC. Technologists are already actively working to augment MOOC platforms with a plethora of products such as tools to support contextual in-text and in-video discussions, formation of study groups and project teams, discussion boards with voting and other features, and ways MOOC learners can connect not only in real time, but also in the real world.

Through conscious course design and A/B studies (1) comparing different versions of its implementation, a MOOC could potentially be engineered to maximize the learning of the collective. Further along in the development of MOOCs, this collective maximization may work in tandem with "mass customization" (Salvador, De Holan & Piller, 2009), wherein the course is restructured at the individual level in order to best support each student, and not only the aggregate. Regardless of how MOOCs are optimized in the near-term or projected future, deliberate thought given to the dimensions of MOOCS where data should be collected—and the appropriate techniques for transforming that data into meaningful indicators of learning, engagement, and distributed intelligence—will serve to provide the evidence needed to warrant changes in course design to lead to measurable improvements.

Next Steps and Conclusion

Crucial next steps that dictate the agenda of our continuing work on this involve outlining granular criteria that capture the various elements of the learning experience in a MOOC designed to leverage intelligence distributed in the different dimensions of the MOOC as described above. Staying true to the "distributed intelligence" perspective also calls for harnessing the experiences and wisdom of MOOC students, faculty and course designers as well in the creation of a robust set of design and evaluation criteria. These criteria would not only serve to evaluate existing MOOCs, but also provide guidelines for the design of future MOOC platform capabilities, and supporting technology tools. They could also inform course evaluation surveys students are expected to fill out after completing a MOOC. Above all, they would help shape a meaningful and timely discourse on MOOC quality.

Endnotes

(1) As pioneered at such companies as Amazon, eBay, Google, Microsoft, Yahoo and Zynga, A/B testing compares relative effectiveness of two versions of a web page to find out which is superior in results for some dependent variable when users are randomly assigned to A or B versions (e.g., clickthrough: Kohavi, Longbotham, Sommerfield & Henne, 2009).

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A Study of Private Messaging Within an Asynchronous Discussion Environment

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Abstract: The study focused on students' use of private messaging as an adjunct form of communication in online courses. Interviews revealed that learners used private messaging to coordinate activity on group projects, request help from each other, and seek reassurance when uncertain about their performance in the course. Public computer conferences, on the other hand, were used for more formal types of academic discourse. Quantitative comparisons of public and private texts revealed that learners wrote longer, more sophisticated and academically rich messages when contributing to the public, class-wide conferences. In comparison, private messages between individuals contained simpler sentences, were easier to read, and were more likely to use jargon. The two forms of communication appeared to serve different purposes. It is proposed that private messaging may help foster a sense of mutual trust among students, which may, in turn, be a necessary precursor to community-building.

Objectives

Distance education research posits the existence of a positive relationship between collaborative student engagement and coursework performance (Graff, 2006). In the context of many online courses, the majority of interaction takes place in threaded computer conferences, where students can share ideas, discuss course material, exchange resources, generate questions, and collaboratively build new knowledge. However, the psychology of such environments is complex. As pointed out by Peters and Hewitt (2010), some students can be nervous about writing to an audience of their peers. While most students appreciate the value of collaborative engagement, they are also concerned about how they are perceived by their instructor and fellow classmates. They want good grades, and thus they are understandably cautious about publicly posing questions that may reveal a lack of understanding, or suggesting ideas that may be vulnerable to critique, or even ridicule. So while the shared nature of a threaded computer conference provides critical affordances for class-wide knowledge building, it can also be inhibiting for some (Peters & Hewitt, 2010).

As an extension of this body of research, we have developed an interest in the role that private messaging might play in online courses. To explore this issue in greater depth, the current study examined an online environment called "Pepper" that contained facilities for two types of interaction: i) a threaded discussion forum in which messages were visible to the entire class and ii) a private messaging system in which students could communicate with each other privately. How did students use these two tools? What were the differences between the writing that occurred in the class-wide computer conference and the writing that occurred in private spaces?

Theoretical Framework

This research is grounded in social-constructivist notions that learning can be fostered in online courses by exposing students to the ideas of their peers, through sustained collaborative discourse about key course concepts. It is through the articulation of one's own ideas, and through efforts to understand the perspectives of others, that learners develop deeper insights (Wise, Chang, Duffy, & Del Valle, 2004). Given the educational importance of these processes (Stahl & Hesse, 2009), the goal of the online instructor becomes one of promoting sustained, educationally productive discourse in a shared electronic space (Bullen, 1998; Gunawardena, 1995; Gunawardena & Zittle, 1997; McDonald & Gibson, 1998; Ross, 1996; Vrasidas & McIsaac, 1999). Discursive interaction is thus viewed as paramount to the success of online learning (Picciano, 2002).

Given this perspective, many instructors attempt to establish a sense of community in their online courses. An effective community is one in which individuals trust each other and are willing to ask difficult questions, constructively critique each other's ideas, and work together collaboratively to build new knowledge. Such communities are thought to have high levels of "social presence", which Garrison (2009) defines as, "participants identifying with the community, communicating purposefully in a trusting environment, and developing interpersonal relationships" (p. 7). Research suggests that higher levels of social presence are associated with people placing greater value on the perspectives of their peers (Swan & Shih, 2005), and a richer exchange of information between learners (Fung, 2004; Henning, 2004; Stacey, 1999).

Social presence can be difficult to nurture in online courses. Text-based communication lacks many of the visual and aural cues that people naturally use when communicating, such as smiling, making eye contact, gestures, and so forth (Gunawardena & Zittle, 1997). Additionally, as Peters and Hewitt (2010) point out, the high visibility of student writing in computer conferences may inhibit social presence. When people submit messages to class conferences, they are typically made available to all students and the instructor. Fear of criticism can prevent people from asking questions, responding honestly to controversial topic, or sharing nascent ideas with each other. This can limit the effectiveness of online interactions. In an effort to better understand this phenomenon, the current study examined a set of distance education courses in which learners could exchange ideas with one another using several forms of online communications, some public (i.e., visible to the entire class) and some private (i.e., between individuals). How were these different forms of communication used, and in what ways, if any, did they differ?

Methods

The study involved an analysis of two types of data. First, we interviewed 10 students from three distance education courses about their online experiences, with a particular focus on their use of private messaging. The purpose of the interviews was to better understand the situations in which they chose to interact privately with their peers. To encourage candid responses, a graduate researcher conducted the interviews and participants were assured that their identities would not be revealed.

The second half of the study was quantitative in nature, involving the analysis of students' private and public contributions in 19 distance education graduate-level courses (363 students). Each course took place in the Pepper environment. Because of ethics-related concerns, it was not possible to view students' private messages. However, our ethics protocols permitted computer-based statistical analyses of aggregate patterns of the text within messages, both public and private (e.g., message size, sentence size, reading ease, etc.). This allowed us to collect data that would help triangulate our interview findings without jeopardizing student privacy.

Each of the 19 distance education courses was 12 weeks in length. Within these courses, students were encouraged to collaboratively discuss various issues in the whole-class threaded discussion area. While graphics or videos were sometimes used, the interaction was predominantly text-based. Students were not required to use the private messaging environment within Pepper, but it was available if they wished to send a private message to the course instructor or a classmate. Course grading schemes typically included a 10% to 20% mark for students' participation in the class-wide discussions. The remainder of their grade was based upon submitted assignments.

For the purposes of this study, we use the term "public" to refer to text-based messages that are posted in the shared computer conferencing area in Pepper. These messages are visible to all members of the class, including the teacher. The term "private" refers to small private, text-based exchanges involving 2 or more of the people in class. Pepper's private messaging facility is similar to the private messaging facilities in Facebook and Gmail. Students in Pepper can see which of their classmates are currently online. A private message sent to a person who is logged in will "pop up" on their screen, giving students the option of chatting in real time. Messages sent to people who are offline are saved until the next time they login.

Results: Interviews

An analysis of the interview transcripts yielded the following findings concerning the most common reported applications of the private messaging facility:

- Coordinating group activity: In classes where students were assigned a group project, students used private messaging to seek out potential group partners, schedule telephone meetings (or Skype meetings) for the group, and assign tasks to different individuals. Students felt that a private forum was more appropriate for these sorts of administrative functions than the public conference.
- Seeking help: Students reported they often used private messaging to obtain information about course deadlines, receive clarification regarding assignment expectations, or to help solve technical problems. Often students would send a query to a classmate who was currently online, since that would generally produce a rapid response.
- Sharing drafts: When students felt uncertain about posting material in the public forum, or in situations where a passage of text was to be jointly authored, students would often use private messaging to exchange drafts and receive feedback from one another.
- Providing peer support and encouragement: Students reported that private messages tended to be upbeat, supportive, and empathetic in situations where people acknowledged that they were struggling. "We connect with each other at a different level in the text messages" according to one student. One individual described a situation in which one of her classmates privately messaged her, asking her to read the note she had posted in the public forum, and write a response to it. "I don't feel like I'm part of the conversation. Would you mind responding to my note?" Thus, in this particular case, private messaging was used to address a student's insecurities regarding the lack of activity surrounding her contributions to the class conference.

When asked to discuss the relative value of private messaging versus email, many students responded that private messaging was more efficient because it was built-in to the software, and thus didn't require them to go to a different application or website. It also provided them with speedier responses, because students could see when their classmates were online, and communicate with them directly. However, in some situations, people didn't trust private messaging. One student recounted a situation in which a discussion moved from private messaging to email. The discussion concerned a sensitive issue (the questionable online behavior of a classmate) and the participants became concerned that the instructor might be able to somehow access their private messages and deem them inappropriate. Consequently they moved their discussion to email.

Results: Quantitative Analysis

The second half of the study consisted of a larger-scale, statistical analysis of differences in the texts of private messages and public notes in the threaded discussions. A comparison of private and public texts across the 19 courses uncovered a number of significant differences:

• Private messages were significantly smaller than the public messages in the class-wide computer conference ($p < 0.001$). Private messages contained an average of 41.08 words compared to an average 186.82 words for public messages. Private messages also contained significantly shorter sentences than public messages ($p<0.001$).

• Private messages tended to be more readable than Public messages. Two measures of readability were examined: i) the Flesch Reading Ease metric and ii) the Flesch-Kincaid Grade Level. Private messages had significantly higher readability scores and lower grade level scores than public messages ($p<0.001$ for both message types). Public notes were written at a 10.67 grade level, on average, while private messages were written at a 4.94 grade level.

• Public messages were more "academic" in tone. The Academic Word List Ratio is a measure of the degree to which a passage of text uses vocabulary that it is common in academic writing. It is based upon the Academic Word List (AWL), a corpus of 3,110 words divided into 570 word families. The list includes such words as "data", "discover", "rate", "theory", and so forth. The contents of the list comprise 10%-15% of the words found in academic texts across all disciplines. However, words in the AWL comprise only 1.4% of the words found in non-academic texts (Coxhead, 2000). In the currently study, private messages had a significantly lower percentage of academic words than public messages. Private messages had 4.4 academic words per 100 words (on average), while the corresponding value for public messages was 7.83 words per 100 words. This difference was statistically significant ($p<0.001$).

• Students used much more informal vocabulary in private messages. Using Internet message boards for source material, we developed a list of 45 informal terms such as "LOL", "yup", etc. Private messages contained 21.92 informal terms per 1000 words, while public messages used 2.06 informal terms per 1000 words. This finding was statistically significant ($p<0.001$).

• Our studies failed to find differences in the "sentiment" of the respective texts. Sentiment analysis is concerned with the level of positive and negative emotion expressed in a passage of text. To measure the positivity and negativity of language, we employed an algorithm that uses a positive word list and a negative word list, respectively, to examine the frequency of positive (and negative) words in students' notes. These lists were provided by a tool called LIWC (pronounced "Luke" - Linguistic Inquiry and Word count). Studies indicate that "LIWC accurately identifies emotion in language use" (Tausczik & Pennebaker , 2010, p. 32). The LIWC algorithm produce scores that range from 1.0 (highly negative emotion) to 9.0 (highly positive emotion). A score of 5.0 is neutral. In the current study, public messages had a mean sentiment score of 6.38, a score that was not significantly higher than the sentiment score for private messages (6.33).

Taken together, the quantitative results appear to be consistent with the findings from the interviews. Private messages are more familiar, shorter, and less academic than the messages that are saved in the public discussion conferences.

Discussion and Conclusions

Although the private messaging facility was an optional component of these courses, students made frequent use of it. Private messages were significantly different than public computer conferencing messages in the following respects: They tended to be shorter, contained simpler sentences, were easier to read, were less academic in nature, and used informal vocabulary. Messages on the public forum, on the other hand, were longer, more formal, and more academic in nature.

Since we were unable to directly analyze the contents of private messages, we used interviews to learn about the students' private messaging practices. Both the interview data and the quantitative analyses suggest that students adopted a less formal style of discourse when conversing privately. According to the interviews, the private discourse provided learners with a place where they could ask ("dumb") questions to a classmate, privately share an idea, or a draft of a text passage, before revealing it the larger group. We suggest that this informality may help foster social presence and interpersonal trust. Asking another person for help or advice is a particularly important step when building trust. Threaded discussion environments are not particularly helpful in this regard; many students are understandably wary about admitting their lack of knowledge in a public forum that is monitored by their instructor.

To create a genuine sense of community, it may be necessary to provide opportunities for participants to interact in ways that lack some of the formality of public academic discourse (e.g., the use of jargon, humor, and "I don't get it" kinds of statements). Learners need a risk-free place where they can "try out" ideas on a trusted classmate before making the ideas public, much in the same way that academic researchers may "try out" ideas with colleagues before attempting to publish the idea in a journal article, or make a conference presentation.

The differences between public and private discourse revealed by this study suggest that conventional computer conferencing, on its own, may not meet all the needs of learners. It is proposed that opportunities for private interaction may be a key ingredient for building student-student relationships. While it may at first seem like a counterintuitive relationship, the trust developed during private, interpersonal exchanges may play an important role in the forging of a healthy, public, online community.

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Factors influencing online collaborative learning: Why some groups take off better than others?

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Abstract: In this work we carried out a case study to understand how some groups “take off” better than others with regards to engaging in the collaborative knowledge construction process in a virtual learning setting. We found that student facilitation was an important contributor to the process. Instead, the contribution of “lower” quality initial postings can jeopardize the process.

Introduction

Consistent with a sociocultural perspective on learning, collaborative learning (CL) is particularly popular in online, asynchronous courses. Typically supported by asynchronous threaded discussion tools, online learners engage in social exchange, discussion and collaboration in an effort to advance their knowledge. Computer supported collaborative learning (CSCL) research has focused on a number of factors influencing the success of CL in virtual settings. Group composition (in terms of gender, status, culture and expertise), size of group, nature of the task and task structuring, participants’ individual characteristics, the role of the instructor and the role of tools/interfaces supporting the learning task, have all been identified as variables influencing collaborative knowledge construction in CSCL settings (e.g., Resta & Laferrière, 2007).

In this study we attempt to advance the research in online CL by focusing on two factors: *student facilitation* and *quality of initial postings*. Prior works suggest that the presence of a student facilitator in asynchronous online courses drives the quality of the learning process and the meaningful construction of knowledge within the online community (Aviv, Erlich, Ravid & Geva, 2003; Garrison & Cleveland-Innes, 2005). Yet there are still concerns that low critical thinking and irrelevant contributions take place when the discussion is guided by peers (Rourke & Anderson, 2002). In terms of quality of contributions, a few studies have focused on structuring online discussions and evaluation rubrics to ensure meaningful discourse and knowledge construction (Gilbert & Dabbagh, 2005). Yet, there seems to be lack of work examining how “good” and especially “bad” postings influence the progression of online discussions and the construction of knowledge. The present study provides quantitative and qualitative types of evidence on how *student facilitation* and *quality of initial postings* influence collaborative knowledge construction in online discussions. With reference to these factors, the study provides a perspective on why some groups “take off” better than others with regards to collaborative knowledge construction in online discussion forums.

Method

The participants were 34 graduate students in two sections of an online “Learning Theories” course, taught over 16 weeks at a public University in Northeast USA. The sample included 79% women (21% men), between 22 and 54 years old (M=37, SD=10.8). Students were randomly assigned in nine groups; seven groups of four students and two groups of three students.

Students were tasked to work collaboratively in their groups on a case vignette. Student collaboration was carried out virtually, using the threaded discussion forum of WebCT. The activity lasted two weeks. To ensure quality, the case vignette was adopted from a book specialized on the case study method by Dottin and Weiner (2001). The case presented an ambiguous classroom problem concerning a 12-year old boy, Joe. The discussion of the case vignette was not intended to promote knowledge acquisition; rather students were to apply concepts learned in the course and argue for plausible solutions based on their knowledge and professional experience. Ultimately, students were asked to produce a consensus plan for Joe’s teacher, suggesting a solution to the problem. In order to guide their activity, students were provided with guidelines on how to approach the analysis of the case vignette (also adapted from Dottin and Weiner (2001)). The discussion was led by the students themselves. The instructor of the sessions monitored the group discussions, but her intervention was purposely restrained to structural feedback only (e.g., “You need to base your arguments on instances from the case and to support those with theory”). During group work, the entire corpus of collaborative discourse of each group was automatically captured in WebCT’s discussion forum.

Data analysis

The analysis was conducted in two levels from (a) coding and counting the group’s discourse in order to understand the general content structure of the discussion, to (b) exploring the collaborators’ contributions as they occurred chronologically and re-examining the discourse in depth to constitute evidence for the role of *student facilitation* and *quality of initial postings* in the collaborative knowledge construction process.

Coding and Counting

After reviewing a number of coding schemes of previous investigations of the process of collaborative knowledge construction (e.g., Aviv et al., 2003; Puntambekar, 2006), we decided to shape our coding scheme on the basis of the "Interaction Analysis Model" proposed by Gunawardena, Lowe & Anderson (1997), which conceptualizes the processes of collaborative knowledge construction in virtual environments as a series of successive phases. The coding scheme was fine-tuned on the basis of the discourse data of the present investigation (approximately 15%). Two coders worked closely together to modify and refine the coding scheme in context and to explicitly decide what aspect of the content constitutes evidence for each coding category: (1) Sharing/ Adding, (2) Negotiating meaning, (3) Elaborating, (4) Evaluating/testing of proposed synthesis, and (5) Consensus/Applying co-constructed knowledge (detailed table can be provided upon request).

The entire corpus of the collaborative discourse of each group was analyzed using the coding scheme. The post was taken as the unit of analysis and was categorized with one of the categories for the phases of collaborative knowledge construction. When in doubt about the phase that should be applied, the contribution was coded in the lower phase, and in clear cases of two or more applicable phases (usually evident in lengthier postings), the contribution was coded in the higher phase. Approximately 50% of the discourse was coded by the two coders simultaneously. The remaining 50% was coded by each coder independently and percentage agreement was computed to be 89%; disagreements were resolved by discussion between the coders.

We then calculated frequencies of the coded phases per group as in Table 1. The distribution of codes in each phase helped us understand the general content structure of the discussion in terms of phases of collaborative knowledge construction. Table 1 presents the number of codes across phases and groups.

Table 1: Number of codes across phases and groups.

	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	*Total*
group1	3	3	2	6	1	*15*
group2	10	2	5	2	1	*20*
group3	7	2	2	3	1	*15*
group4	4	4	3	2	1	*14*
group5	13	7	6	6	1	*33*
group6	20	5	19	4	2	*50*
group7	7	10	13	8	4	*42*
group8	9	4	7	11	2	*33*
group9	7	14	3	5	1	*30*
Total (%)	80 (32%)	51 (20%)	60 (24%)	47 (19%)	14 (6%)	*252 (100)%*

Chronological Visuals and In-depth Examination of Discourse

Using chronological visuals, we further explored the collaborators' contributions as they occurred chronologically while re-examining the discourse in depth (beyond aggregate counts of posts) to constitute evidence for role of two factors -- student facilitation and quality of initial postings – in the knowledge construction process. This analysis was inspired by Hmelo-Silver, Chernobilsky & Nagarajan's (2009) CORDTRA visualization technique.

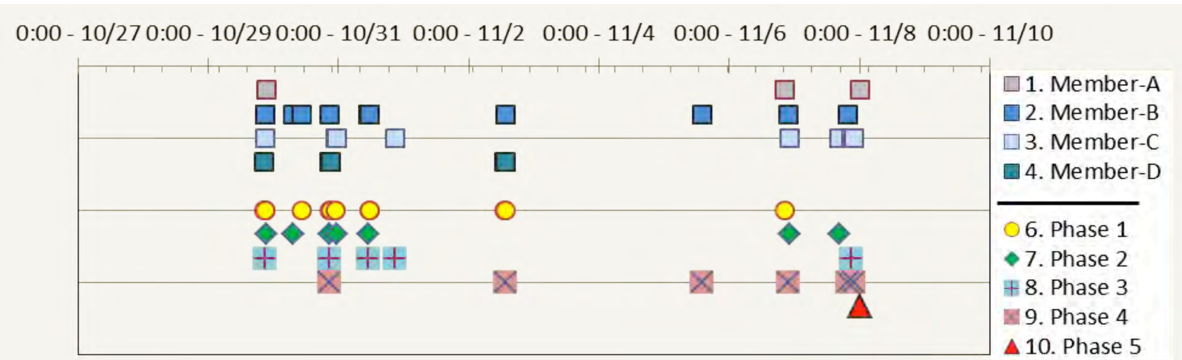

Figure 1. The chronological visual of Group 5.

For each group, we generated an Excel scatter-plot using the groups' coded discourse. See for example Figure 1 for Group 5 (all other visuals can be provided upon request). The time of the contribution runs at the top of the visual in chronological order (e.g., 2-weeks duration of the activity). Collaborators and discourse categories are listed on the right of the visual, while each time-point on the visual represents a collaborator and his/her contribution in the knowledge construction process. The analysis begins by inspecting all visuals for patterns. Then, the knowledge construction process is examined in more depth by "zoom in" on the areas of each diagram where patterns exist and by going back and forth between the visual and the group's discourse.

Results

Considering Table 1 and the visuals of all groups, our attention was drawn to particular groups which appeared more or less successful. These groups were examined in depth (beyond aggregate counts of posts) in relation to the factors of interest in this study: student facilitation and quality of initial postings.

Student facilitation

The detailed examination of the groups' discourse, by going back and forth between the visuals and the discourse, showed that groups with an emerging student facilitator appeared more successful in their collaboration compared to other groups. Using an empirical, bottom-up approach we identified that student facilitators possessed core presence in guiding and structuring the discussion toward the final product, participated frequently often undertaking the summarization of the points and ideas articulated (by themselves and others), and their contribution was acknowledged by their colleagues. A student facilitator was evident in two out of the nine groups of the study: Group 5 and Group 8.

In particular, considering the visuals of Groups 5 and 8 in relation to the visuals of all other groups and the counts of Table 1, these two groups appear successful in engaging in the collaborative knowledge construction process for several reasons: 1) there were contributions along all phases of knowledge construction, 2) all group members participated in the discussion, 3) there were not too many contributions (e.g., >40), which could be suggesting difficulty in coming to a consensus, and 4) there were not too few contributions (e.g., <20), which could be suggesting limited engagement with the task. The groups' discourse allowed us to understand the specific activities undertaken by the emerging leader over time, as well as the quality of the contributions in these groups.

In both of these groups the student leader (female in both) emerged in the early stages of the discussion. In Group 5, the leader (Member B) took the initiative to describe the situation and define the problem making sure she set out common grounds of discussion with the rest of the participants. Upon interaction with the other group members, she next tried to identify secondary issues and revise the problem definition. She often (from the beginning until the end) summarized the other students' postings evaluating and extracting the central ideas that would construct the final argument. Managing time in view of the assignment deadline was another initiative on her behalf. Overall, her postings were lengthy but not authoritative as her tone and style was not discouraging to other group members. She clearly expressed her opinion but at the same time invited others to add to or modify her points. Also, she frequently encouraged and motivated her colleagues to contribute, for example, "Those are some of the thoughts I had today. Some of Joe's issues might be taken care of by a change in the classroom learning environment, starting with classroom management. […] I think [Name] hit on this too! Great job [Name]". At the end, she indicated her satisfaction from their collaboration and appreciated the outcome as a successful one. Her role as a leader was reflected in one of the other participants' posting who, when finalising the group's consensus, said to her: "…Will you take a final look at this and then post it to the group consensus discussion? I can do this, but I don't want to post without your final 'once over'".

The student who emerged as a leader in the Group 8 (Member B) demonstrated similar facilitation patterns. She took the initiative to start and direct the discussion, and although this group had a rather late start in the activity, they worked intensively during week 2, engaged in all phases of the collaborative construction process and managed to complete the task on time. Her postings, albeit not lengthy, inspired the contribution of the rest of the participants, for example, "You did a lot of work for all of us on "Readers Workshop" and "Responsive Classroom". Thanks [Name]!" She frequently integrated the several contributions into one summary document while leading the discussion under a critical evaluation angle. Also, she often reviewed and monitored the group's progress. Her colleagues recognized her significant contribution, as shown in comments such as: "Your hard work really helped me out a lot." She contributed the most up until the end of the discussion, occasionally giving the impression that she did so trying to meet her colleagues' expectations: "Ladies, we are almost at the end!!! I am not sure who wrote the closing paragraph, but it pulled things together well. I added to it and I am posting here again for final comments/edits/revisions."

In both groups, the emerging student leader often drew from theories in the course textbooks and readings to initiate discussion in some direction, for example, "Are Joe's nonacademic needs being met? According to Ormrod (p.486), students are more likely to focus on their schoolwork when their nonacademic needs have been met." (Group 8 leader). In other cases, the student leader, drew from their experience and, with examples from their teaching practice, they indicated how they would respond to the problem described in their case study activity. In this way, they encouraged the rest of the participants to construct and elaborate on those examples. For example,

> "Based on my experience, the teachers would benefit from finding out what Joy's interests are. While he seems to be ok in math, the teachers of other subjects would do well to find out what other areas of knowledge he is confident about. They could use his interests to help spur work in language arts, reading, science, social studies etc..." (Group 5 leader).

Last but not least, in Groups 5 and 8 where a leader emerged providing facilitation, there was less confusion while the discussion naturally progressed through, and reached, all phases of collaborative knowledge construction. In contrast, Groups 1-4 demonstrated limited engagement in all phases of knowledge construction; in fact, these groups shared the workload to get the task completed (i.e., cooperation) while collaboration was limited. On the other hand, Groups 6,7,and 9, although engaged in the process, they experienced difficulty summarizing their views in cohesive arguments – a task undertaken but the emerging student facilitator in Groups 5 and 8. This finding further constituted empirical evidence of successful collaboration in Groups 5 and 8 enabled by the facilitating role of the emerging leaders.

Initial postings of low quality

Our detailed examination of the groups' discourse suggested that the contribution of "lower quality" postings in early stages of the discussion can jeopardize the collaborative knowledge construction process. This kind of behavior was evident in two groups (out of 9) of the study, particularly Group 2 and Group 3. In both of these groups a participant started their initial ideas (Phase 1 statements) in bulleted form. Then, this formatting was adopted and continued by other participants and for the vast majority of the contributions. In general, the postings in bulleted form were undeveloped statements which did not seem to encourage further discussion, thus we can fairly characterize those as "lower quality" postings. Overall, Groups 2 and 3 were less engaged in the collaborative knowledge construction processes compared to all other groups, as evident both in the counts of Table 1 and the visuals. This constitutes evidence that postings of low quality contributed in the early stages of the discussion can jeopardize the progress of collaborative knowledge construction. Unlike Groups 2 and 3, all other groups presented initial postings of better quality in the sense that these postings were well-developed and communicated ideas in a narrative and meaningful way.

Conclusion

The study provides a perspective on why some groups "take off" better than others with regards to collaborative knowledge construction in online discussion forums. In this work, we found that student facilitation was an important contributor to the process. Instead, the contribution of "lower" quality initial postings can jeopardize the process. A discussion of these findings in relation to previous research as well as directions for future research are included in an extended version of this manuscript (please contact the authors for a copy of the long manuscript). Our findings, although tentative and demanding replication, can inform both the instruction and design of online discussions and group activities aiming to promote collaborative knowledge construction.

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Bridging Networked Learning Across Multiple Levels: Participatory Approaches to Competency-Based Learning

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Abstract: This paper describes new work that is currently exploring how participatory learning can be fostered in a competency-based system. By using a new curricular framework, a system of leveled digital badges, and a Ning, this work incorporates methods and insights from the CSCL community, which is helping to engage a difficult population in meaningful discourse around complex and abstract concepts in concrete contexts.

As MOOCs and digital badges are emerging as part of the educational sphere, it is becoming clear that our definitions of what it means to "learn" and to "know" – and therefore what classroom learning looks like – must be adapted to include these new technological movements. Henry Jenkins' (2009) notions of participatory culture may not have initially been intended for classroom settings, but a new approach to instructional and assessment practices that embraces situative views of knowing and learning (e.g. Greeno, 1998) provides an opportunity for participatory culture to converge with the knowledge outlined in the prevailing standards-based educational reforms. This approach creates occasions in the classroom where meaningful discourse around complex concepts and self-reflection can take place in grounded and increasingly formal contexts.

This curricular framework emerged out of earlier work inspired by situative approaches to assessment and takes a broader view of learning than conventional behavioral and cognitive theories (Gee, 2003; Greeno & Gresalfi, 2008). This leads to a broader view of what constitutes "assessment" (Hickey & Anderson, 2007) that blurs the distinction between instruction and assessment, and argues that all learning involves assessment. The approach allows assessment to take on a "transformative" function, positioning assessment *as* learning, and assumes that assessment has the power to transform learning ecosystems. This paper discusses how a recent implementation, coupled with the introduction of a digital badging system, is allowing assessment to serve summative, formative, and transformative functions for different types of learning while fostering participatory engagement and indirectly but consistently impacting student understanding and aggregated achievement.

Participatory Learning and Digital Badges in a Competency-Based System

This research was initiated in 2008 as collaboration between a University-based team of assessment specialists, a curriculum development effort led by Jenkins' Project New Media Literacies, and a gifted English teacher. This collaboration refined emerging sociocultural approaches to informal and formal classroom assessment around a comprehensive new media curriculum organized around a classic text. These assessments structured increasingly formal activities, where the initial activities are more informal and participatory, while the later activities are more formal and standards-oriented. The assessments are designed to provide students and teachers with embodied contexts to experience the way that academic knowledge takes on different meaning in different contexts. The assessments provide a dynamic balance of summative and formative feedback that is used to shape (1) the classroom's social learning of the shared literary practices, (2) each student's individual learning of underlying concepts and skills, (3) the teacher's learning to enact and refine the module, and (4) the overall impact of the instructional-assessment ecosystem on external achievement.

A driving force behind this work is an effort to foster productive disciplinary engagement (PDE), where engagement occurs around valued concepts and skills, and aims to engage learners in connected learning, bridging the gap between academic settings, peer culture, and interests.

When the MacArthur Foundation launched its Badges for Lifelong Learning Initiative, we saw an excellent opportunity to further our research and continue our efforts to resolve the tensions between participatory practices and competency-based accountability policies. At their core, badges are really just an easy way to show off someone's skills and achievement. This means that they can act as credentials for learning in any setting, including that of a classroom. The learning represented by badges can be small achievements like completing an assignment or they can represent an accumulation of several smaller achievements that lead to mastery of a concept in a domain. As credentials, badges for competency-based learning have great potential because they can be "leveled" to represent the degree of mastery a student has attained in a particular competency. Digital badges are being implemented in many different settings, but many are doing so from a conventional competency-based approach that is not consistent with Connected Learning. We are combining our curricular approach with a digital badging system to foster participatory and connected learning in a competency-based learning system.

One instance when digital badges and this curricular framework came together was in a literature circle unit as the research team collaborated with an ELA teacher at an alternative high school that serves students who did not fare well in the mainstream high schools. When the school opened in 2010, the district partnered with an organization known as *Diploma Plus.* The Diploma Plus Competencies are part of a standards-aligned approach that outlines the critical thinking skills needed to master core knowledge in rigorous and relevant ways. They provide teachers with a framework to authentically assess students at increasing levels of proficiency.

As part of our ongoing work and in an effort to help this population succeed, we designed a module where students took on different "roles" for reading each section of a book, and allowed those roles to shape their understanding of (a) the text, (b) the Diploma Plus Competency of developing meaning in a text, and (c) the skill of identifying and analyzing themes that emerge in a text as outlined in the Common Core Standard in a participatory setting. This module also engaged students in networked learning, which is quickly becoming a basic skill for all students.

The teacher had struggled to incorporate the Diploma Plus Competencies into her curricula and sought assistance from the research team, who saw leveled digital badges as a way to both integrate these somewhat abstract Competencies meaningfully into a curricular unit and provide the students with concrete visual representations of what they were working to master. We implemented smaller peer awarded marks of recognition called *Stamps of Approval* that are being used in a hybrid post-secondary course and other ELA courses in local high schools as a way to motivate students while they engage critically with the content. In this implementation, stamps are posted as comments to the blogs and indicate that the author had impacted the commenter's thinking in a significant way. These stamps serve transformative assessment functions in that the activities become not only opportunities to demonstrate a student's grasp of the text and concept in the Common Core Standard, but a forum for self-reflective thinking and discussion.

More substantial teacher-awarded badges were designed to reflect the level of a student's mastery of the Competency. The metadata of the badge holds pre-determined information about the level of the badge and the Competency for which it is awarded, and customized information about what a particular student did to earn the badge. In this badging system, the teacher uses the stamps as flags to draw her attention to specific features of, in this case, a blog influenced learners' understanding, and assesses the blog with those stamps in mind. While the stamps do not determine the awarding of a badge, the interactions suggest that students are thinking critically and reflectively about the skills outlined in the competency.

Engaging a Challenging Population

The student population is challenging, as they each come to the alternative school with vastly different skill sets and motivations, as well as different emotional and mental issues. Many of these students have failed multiple times in other scholastic settings and have been pushed out of the mainstream schools into the alternative school. While class sizes are small, one class of fifteen students can include students who do not read or are beginning readers and others are reading above grade level. This, combined with the students' differing motivations to learn and engage with the content, poses a great challenge for the teacher, as they must design curricula that accommodates the varying educational and engagement levels to make sure every student has the opportunity to succeed, even if they choose not to take advantage of that opportunity.

Building on arguments articulated in Koschmann (2011), the goal of this design research is building local theories in the context of this particular practice to understand and enhance participation in scholastic practices. To this end we are using the guiding principles of the above mentioned curricular approach (Hickey, Honeyford, & McWilliams, 2012) and networked learning spaces to foster PDE and connected learning in a competency-based system.

The teacher found it difficult to motivate students toward their competencies or even know at what level they were performing. We quickly realized that digital badges were a way for the students to literally see their level of performance and what exactly constituted a Competency. These badges are leveled as One, Two, and Three Star Badges that correspond to the competency levels. From earlier collaborations with this research team, the teacher has fully integrated the use of a Ning in many of her classroom activities. While the networked collaboration that occurs on a Ning might at first seem at odds with these Competencies, bringing the two together presented an opportunity to (a) explore whether the principles of the curricular approach and the technology of digital badges could (b) help the teacher foster connected and participatory learning within the Ning network, while (c) working within the competency-based learning framework.

The next step involved finding ways to foster PDE and connected learning within this system of badges and competencies. It became apparent that, rather than just awarding badges at the formal summative level, smaller stamps of approval could reward engagement at a semi-formal level which could help engage and motivate students. These stamps were awarded simply by putting the symbol !!! before a comment that explained how the post articulated something well, furthered conversation, helped the commenter understand a concept, or was otherwise exemplary. The stamps served the purpose of (a) rewarding exemplary work, (b) providing an opportunity for the commenter to think about their own learning and engagement with the activity, and (c) alerting the teacher to interactions and learning that might have otherwise gone unnoticed.

Once the stamps are awarded, the teacher uses these as a tool to help her award formal badges, and as a teaching tool for the next round of blog posts. Students can look back at the comments in the stamps to see what they did well, and strive for that kind of work again. These stamps also serve as a starting point for a larger discussion about reflection on practice and learning. By making their smaller and larger accomplishments visible, the teacher empowers the students with the ability to literally see and reflect on their accomplishments. The badges contain very concrete characteristics, and mean something beyond the context in which it was earned. If students share these badges out to Facebook or Twitter, their friends can see concretely what they learned and how they learned it.

Productive Disciplinary Engagement (PDE) in a Competency-Based Badging System

A major component of the literature circle module involves the students posting blogs to the class Ning about their reading through the lens of their assigned role. Students read, comment, and stamp each other's work. The Ning is a mediating space for fostering PDE within a competency-based framework and badge system. Drawing on Engle & Conant's (2002) principles, we present students with the a learning environment where they can participate meaningfully both with the content and with one another around some very complex and abstract competencies, making an otherwise be a nebulous task of "developing meaning" (Diploma Plus) concrete.

Problematizing Content: The Ning serves as the working space for students to post blogs about their reading through the lens of their assigned role. Because the online format of a blog is less formal than more traditional writing assignments like an essay, this affords students the opportunity to write out their thoughts and connections to the reading in a safe space while tackling the fairly complex and abstract issue of making meaning of a text's themes. Comments and stamps allow the students to receive feedback informally and in a positive and productive manner; instead of critiquing the blog itself, students write comments and award stamps that celebrate and critique the way the blog reveals themes and explains real world connections to the text. The Ning blogs are easily edited, so the students can explore the idea of theme and the different themes they feel are present and relevant, receive feedback from their peers and teachers, and revise their work as they feel appropriate. Grappling with developing the meaning of "theme" in general and of the themes emerging in the text is no easy task, but students seem to feel comfortable in testing out their thoughts on this problem in this space, as is evidenced by their postings and revisions.

Giving Students Authority: In addition to providing a place to explore ideas, the Ning has become a space owned by the students. While the teacher posts comments to the blogs, she does not provide direct critiques or instruction in that space, but encourages the students to read with a critical eye and engage in conversation about the claims being put forth. Student ownership is evident in the way students comment and push back on the concepts and thoughts put forth in the blogs, using causal language and offering apologies with their critiques. This language indicates that the students feel their peers will read the feedback and take it seriously, so they too must take the commenting seriously. In oral classroom discussions the students reference specific blog excerpts and comments. The roles also help give the students authority over the space and their work. Eight of the twelve blogs that have been posted relate the book to real life situations, and several are written in the first person, taking on these events as though the students are living them. Eight of the twelve blogs posted contain some kind of analysis of the text, and five of the blogs include outside research references. The students have done more than report on what they had read; they are taking on their role as summarizer, investigator, or researcher and really analyzing the text to find meaning in it.

Holding Students Accountable: The openness and visibility of the blogs posted on the Ning also provide a sense of accountability for one's work because the students' names appear in big bold letters next to the title of the blog. Students know that what they post to the Ning will be read by their peers, which – the teacher surmises – is leading to the students enlisting their teacher's expertise before posting to the blog. Most students are choosing to write their blog as a Word document and ask their teacher for grammatical and general feedback prior to posting. This is particularly remarkable given the student population and their previous seeming lack of concern for the quality of the products they produced as reported by the teacher. The teacher remarked that this assignment is the first time the students really seem to care about what the product looks like before it is posted, and she posits it is because the students know their peers will be reading it. Once the blogs are posted, the comments and stamps keep the students accountable, as many of them provide critiques along with the acknowledgement of the work that the student completed. Comments like this one are beginning to surface:

> I think that your blog was pretty good because you played your role well. I liked how you connected and pointed out certain things such as gangs relating to graffiti. I thought that your blog had good information in it, it (*sic*) helped me at least understand different themes in the book i (*sic*) never looked at. The only part in the blog I quesitoned (*sic*) was when you said "That's how I was told to write this blog. There are many things that I could talk about." I felt like those 2 sentences were something when your (*sic*) writing you should just keep to yourself because it almost sounds rude and unprofessional (NO OFFENSE KENSEY). I think over all the blog was a success.

We were surprised that this and many comments like it were not labeled as a stamp. When asked about it, the student who posted this replied that she wasn't going to give a stamp unless someone really deserved it, and since this comment points out some flaws, it did not deserve a stamp. This student later changed her mind and went back to stamp the post. This indicates that the students are taking the stamps seriously and only want to award them to those who truly deserve it. While the students have not stamped as much as we had anticipated, those who gave and received stamps generally tend to write more and explain their points more carefully in subsequent posts.

Providing Relevant Resources: While the alternative school provides each classroom with class sets of netbooks and student accounts to access the Internet, the teacher has done a lot of work to integrate the Ning into her classroom practice. Prior to this assignment, students had been introduced to the Ning with informal discussion forums about various topics being covered in the class. While the students had not blogged before, they were familiar with the site and had experience navigating it. In order to introduce them to blogging, the teacher first discussed with the class what blogs are and how they are used in social media, and asked the students to think and talk about times when they might blog about a topic. The teacher then provided the students with some example blogs about some celebrity news the students had been overheard talking about the week before the unit began. Students were asked to reflect on how this piece of writing was different than a traditional essay, and how and when this form of writing might be more effective and appropriate than the essay format.

Summative, Formative, and Transformative Functions of Assessment

The formal leveled Competency badges awarded by the teacher serve a summative function in that the students receive an indication of their performance for this unit, but they also serve a formative function because students can be awarded a badge more than once. Because each badge has a personal comment specifying why the student earned the badge at a certain level, the student has a concrete idea of what they have done and what they can do to move up to the next level.

The peer-awarded stamps serve a formative function through the comments attached to them, but the truly exciting element of the stamps is their transformative function. Instead of reading and critiquing each other's writing, the students write reflective comments that reveal their critical, consequential, and collaborative engagement with the complex concepts. This means that the space in which the students are participating allows the students to constantly assess their own engagement with the concepts while providing opportunities to adjust their behavior as they see fit.

"Knowing" and "learning" in this classroom take on the form of collaborative participation, and the assessment practices allow students to learn as they are being assessed at different levels. These broader views of knowing, learning, and assessment are becoming more important as networked learning becomes an essential skill and students' needs change with the ever-changing technological advancements and integration of technology in the classroom. It seems by embracing these broader views of knowing, learning, and assessment, it is possible to promote participatory, connected learning in networked settings within competency-based instruction.

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Learning through Computer-Assisted Collaborative Game Design: Mathematical, Design, and Computational Thinking

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Abstract: Employing a concurrent mixed-method research design, this study examined the potential of computer-assisted, collaborative game-design activities in promoting design-based mathematical thinking for school children. Sixty four middle school children, with a high percentage of Native American and Hispanic students, participated in a six-week mathematics game design program. Data were collected via in-field observation, design interaction analysis, interviewing, and an attitudes survey. The findings indicated that the design-based interaction and programming-oriented problem solving processes embodied mathematical thinking and reinforced positive attitudes toward mathematics. On the other hand, the prioritization of world/character design and the cognitive demand of computational programming led to a superficial integration or representation of mathematics in children's design products.

Introduction and Theoretical Perspectives

Constructivist and enactivism learning theories argue that learners actively construct knowledge out of their experiences, especially when they are engaged in building objects (Papert, 1980; Kafai, 1995; Li, 2012). Rooted in this theoretical disposition, this study postulated that school children, by collaboratively creating computer math games, will work on and explain the math concepts and problems during design activities. Particularly, students will engage in two learning interactions that transform collaborative, creative activity into mathematical thinking – learner-design interaction and game-design-based social interaction

Interaction between students and the game-design task: A math game-design task may be deemed as a microworld, a promising tool for the development of mathematical thinking (e.g., Mitchell, Kelleher, & Saundry, 2007; Roblyer & Edwards, 2000; Shaffer, 2005). As students design a math game, they will need to explore, represent, and test their mathematical thinking and integrate them into a game's play mechanics. The process will help students articulate, self-check, and constantly accommodate their prior mathematics mental framework (Shaffer, 2005). Empirical research on the use of design practices as contexts for math learning (e.g., Kafai, 1995; Kolodner et al., 2003) indicates that students can "formulate mathematical conjectures during, and as a consequence of, their design activity" (Shaffer, 2005, p. 7). These mathematical conjectures, representing students' ability to "form inferences about general principles from specific observations", are significant for mathematical understanding (Davis & Hersh, 1982; Fitzgerald, 1996; Shaffer, 2005, p. 7).

Interaction between students and design partners: During the design process, middle school children will explain the math topics they have valued and explore alternatives of gameplay quest to represent these topics. Design partners can provide feedback and prompt each other to elaborate more conceptual insights or mathematical reasoning. Self-explanation and communication in mathematics thus become necessary and motivated. In the research literature, self-explanations have been identified as one important factor for enhancing and correcting students' understanding of mathematics concepts (VanLehn, Jones, & Chi, 1992; Wong, Lawson, & Keeves, 2002). Teachers or adult mentors then can act as critics who not only facilitate mathematics communication but also model the in-context usage of mathematics vocabulary that gives young learners the means of communicating math concepts universally.

Methods

An in-situ, mixed-method case study approach (Yin, 2008) was used to examine the phenomenon of learning through collaborative design within computer gaming contexts. The study focused on two research questions: (1) What nature is the collaborative-game-design-based cognitive and interaction processes for inviting and sustaining forms of mathematical thinking (i.e., representation, communication, and reasoning of mathematics)? (2) Has participating in computer math game design helped students to develop positive attitudes toward mathematics?

Sites and Participants

The study was conducted in a rural pueblo school of Native American students and an urban school with a high percentage of Hispanic students. Sixty-four middle grade students were recruited from the two schools, with around 20% of participants being Native American, 80% being Hispanic, and 43% being girls. A group of education graduate students, along with two middle school teachers and the researchers of the study, acted as mentors who provided design and technical support during the game design sessions.

Design Task and Procedure

Iterative Design processes

In this study, students were first probed to identify a mathematical concept or procedural skill that they considered important (e.g., percentage and ratio, multiplication and division, as reported by the participants). They were then requested to create a mini-game to explain the concept or afford the learning of the procedural skill. The game design activity lasted for 6 weeks with 2 one-hour sessions each week. The design sessions took place at the two schools' computer labs. Before performing the game-design task, student participants had all played a selection of exemplary computer mathematics games over a month. A debriefing session was set to probe them to reflect on the games that they had played and discuss on game world and play actions that had engaged them in math learning. They also received training on using *Scratch*, a 2D programming environment designed and developed by the MIT Media Lab for children and youth.

The game design task was semi-structured, following the proposition by the prior research on game-design studios (e.g., Sotamaa 2005) and learning-through-design programs (e.g., Kafai 2006; Kolodner et al. 2003; Shaffer 2005). Different design groups were seated at different tables. Every group generally went through the following design procedure: (a) identifying the target math topic and design goal, (b) brainstorming on solutions to the design challenges, (c) sketching to describe and demonstrate the design ideas, and (d) *Scratch*-based computer game development. To reinforce interaction and collaboration, we requested every member of a design team to take on a particular role based on his/her expertise and interest, such as the team leader, artist, leading developer, content expert, creative writer, and design assistant.

During the first phase of the design task, students focused on paper-based prototype development. They were told to share, accumulate, and negotiate their design ideas via paper sketching. When a *paper-based design prototype* was ready, a design group then moved to computer stations and engaged in computer-based *functional prototype* development during the remained sessions. They were provided a Scratch-oriented *prototype template* sheet in which they had to further specify their design ideas from a computational programming perspective, including the number and outlook of the characters (called *sprites*), the world description, and the major play actions. *Scratch* was used as both a development and a cognitive tool to further externalize, refine, and embody students' design ideas. In the end, all design groups were requested to upload their computer game prototypes to the Scratch web site. A post-design group debriefing session was set to make student designers evaluate and reflect on their design artifacts and experiences.

A group of graduate students, who majored in education and were enrolled in an educational game design course, facilitated all design sessions. They answered both design and content questions, gave feedback between design moves, and occasionally prompted children participants for idea elaboration or math content explanation. They also provided help on *Scratch* programming during game development.

Design-Based Programming

Scratch, a programming environment designed and developed by the MIT Media Lab, was used as students' game design tool for this project. *Scratch* has been implemented and reported on in multiple recent studies that involve computer-supported learning and learning-though-game-design workshops for school students (e.g., Emmerson, 2004; Manroy-Hernández & Hill, 2010). Prior research indicated that *Scratch* is user-friendly for school children who can learn mathematical and computational ideas by creating and sharing Scratch projects.

Data Collection and Analysis

This study utilized both qualitative and quantitative data collection and analysis methods. Data were collected through in-field observation on the game design interactions and activities, interviewing, and an attitudes survey.

The researchers of the current study have conducted categorical aggregation analysis (Stake 1995) with design conversations and observed activities to examine key patterns of design-based cognitive and interaction processes. The design discourses throughout every session were recorded and coded. The researchers of the current study conducted *categorical aggregation analysis* (Yin, 2008) with the transcripts and infield observation notes to examine the function and content of design interactions, and potential evidence of mathematics learning and thinking within design processes, by coding the critical properties of meaningful actions or instances and classifying them into aggregations. Via a systematic coding method (Marshall & Rossman, 2006), we then reduced and summarized the coded data based on the aggregations emerging from the data. The analysis of all qualitative data contributed an initial list of themes that depicted facilitators' experiences and perceptions, which were then refined and extended via a constant comparison, pattern matching and frequency coding. Peer debriefing and member checking were part of the data collection (Lincoln & Guba, 1985). Peer debriefing consisted of formal reviews of data among the coders of the study data. Member checks were conducted informally with participants during the process of data collection.

A group of purposefully sampled student participants were interviewed at the end of each design session for their perspectives of game design and learning experiences. A qualitative thematic analysis was conducted with the interviewing scripts to examine recurring themes, which were then compared and congregated with the findings of in-field observation and transcript analysis results.

All student participants completed the *Attitudes towards Math Inventory* (ATMI, Tapia & Marsh, 2004) before and after the game design intervention. This five-point Likert-scaled inventory is a 40-item survey, assessing students' attitudes toward mathematics with a focus on four identified factors: self-confidence, value, enjoyment, and motivation. The KR-20 reliability of the inventory in this study was 0.87.

Student participants' scores of a state assessment of general math achievement before and after the tutoring program were also collected. In the urban Hispanic-serving school, state assessment scores of both participants and non-participants were collected; in the rural pueblo school, all of the 13 middle school students were participants and hence there was no static control group.

Results

Potential Impact on Attitudes toward Mathematics

A pairwise t-test was conducted to compare all student participants' attitudes towards mathematics in pre-intervention and post-intervention conditions. The t-test indicated a significant result, $t(62) = -2.56$, $p < .01$. The result indicated that participants in this study had developed significantly more positive attitudes toward mathematics after participating in the team-based game-design activities.

The survey finding got corroborated by the qualitative interviewing results. In particular, the following comments had highlighted how participants re-interpreted math:

> *It's like you are learning new ways (on) how to like make better games and stuff. It's like making you practice this for the future and if you want to study then you can get practice over that.*
>
> *You could make it like square root and stuff instead of adding and subtracting.*
>
> *Math is everywhere, like math is in everything you have (to) do.*
>
> *I learned that even though math is everywhere you still have to learn it and when you learn it you will see it more in life that it will be in everything you do. Like cooking, technology, practically everything.*

The aforementioned comments, notably, had encompassed raised awareness of math's value, a broadened expression of math content (e.g., "square root instead of adding and subtracting"), a proactive disposition towards math learning (e.g., "when you learn it you will see it more in life"), and confidence on "new ways" to math learning (e.g., "you can get practice over that").

Nature of Collaborative Game-Design-Based Cognition and Interaction

The analysis with the qualitative data is not fully completed when this proposal is submitted. But three salient themes depicting the nature of collaborative game-design-based cognition and interaction have emerged from the data. These themes were outlined below.

<u>Mergence of Mathematical Thinking and Computational Problem Solving</u>

A mergence between mathematical thinking and computational-programming-based problem solving had been frequently observed and coded from participants' design interaction and their programming artifacts. During Scratch-based game programming, participants were heavily involved in customizing motion scripts of other game cases to realize their design on game actions. During the process, they had: (1) developed solid conceptual understanding of variables and coordinates through analyzing and replacing numerical values of control variables and defining locations and motions of each charter, (2) demonstrated procedural accuracy and quantitative reasoning in computing background transitions and syncing multiple motions via control loops, (3) modeled with math by creating math-relevant simulations (e.g., a car distance calculator), and (4) showed conscientiousness for problem solving during the iterative process of debugging, testing, and refining. Notably, mathematical thinking development was more observed among children who were found reluctant to perform critical thinking during previous game play activities.

<u>Embodiment of Mathematical Communication in Design-Based Interaction</u>

During design-based questioning and clarification, mathematics was found to be adopted and learned as a situated, contextualized design language, especially when the design teams were involved in decomposing a design goal and generating solutions. It was observed that the collective development of mathematics vocabulary in a design team had been reinforced by varied, distributed memory among individual members on mathematics concepts and math game cases played.

During the design talk, there was a presentation preference for algorithms over explanatory narratives. When designing math-related game quests, most children simply presented a challenge via a formal algorithm (e.g., "4 x 7 = ?") rather than situating or visualizing a contextualized word problem (e.g., "There are seven rocks in each box. That is total of …"). Correspondingly, 45% of their design prototypes simply displayed math elements as algorithm equations.

Dissection between Design, Computational Thinking, and Mathematical Representation

Content preference for procedural skills over conceptual presentation: When pondering on the math content to be addressed by the game, almost all student designers voluntarily guided their design thinking via the question, "*Where* will I *use* math in real life?" Accordingly, they tried to establish the scenarios and contexts before considering the gameplay mechanics or content integration, and focused on the practice of procedural skill (e.g., a numerical calculation) as the major learning goal of the games to be created. Few participants gave consideration to the question of "*What* does math *mean* in real life," and hence rarely represent or explain a math concept within their games.

Design versus learning: Design elements could distract student participants from learning. For example, students, especially girls, were observed actively searching and designing game characters and visuals while ignoring the programming of game action and feedback – the design elements that were found as more learning-related and deemed more effortful.

Implications of Research

The study findings should help to generate a clearer profile of learning through collaborative design in computer game and mathematics learning settings. This research should serve as a catalyst for insight and increased research in learning through collaborative design as well as inform the design and implementation of a game-integrated collaborative learning system.

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Is there evidence for expertise on collaboration and if so, is it domain-specific or domain-general?

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Abstract: External scripts have been widely used to guide computer-supported collaborative learners, yet little attention has been given to the internal collaboration scripts. These internal scripts can contain procedural knowledge, which is elaborated, organized and flexible. Is there evidence for expertise on collaboration and, if so, is it domain-specific or domain-general?
If there is expertise on collaboration the retrieval of rich internal collaboration scripts should be differentiable from the retrieval novices' scripts. In two studies collaborative experts and novices of the domains academia and medicine were confronted with stimuli, in which people were involved in, sometimes technology-supported, collaborative activities. To test for domain-specifity stimuli differed regarding the same vs other domain as the subject. The answers were subsequently coded.
There is evidence for expertise on collaboration as the results show that experts retrieve more script-like information overall. The difference was significant for stimuli regarding the same content domain, thus indicating domain-specifity.

Background

Collaborative learning research has made a case that through participation individuals gradually internalize collaborative practices and use these skills in other contexts as well (Kolodner, 2007). It is argued that experts have a better organization of procedural knowledge structures (Fischer, Kollar, Stegmann, & Wecker, 2013). An expert in collaboration should therefore have elaborated procedural knowledge regarding collaborative situations (internal collaboration scripts), while novices scripts are not as elaborated. Collaborative experts should be defined as those who consistently collaborate and outperform others in collaborative situations. It is an unanswered question how to empirically and reliably assess the difference between novices and experts internal collaboration scripts.

A substantial difference between other expertise domains and expertise in collaboration is that a second domain, the content domain, is needed, in which the experts collaborate in. It is an open empirical question whether experts in collaboration in one content domain can apply their internal scripted knowledge when confronted with a collaborative situation of another content domain.

We investigated the following explorative research questions in two studies, which have not been addressed systematically so far.

Is there evidence of collaboration expertise?
To what extent is collaboration expertise domain specific?

Hypothesis study 1

When confronted with a collaborative situation collaboration experts should be able to easily recall their internal collaboration scripts, while novices do not yet have these knowledge aspects.

Hypothesis study 2

If collaborative expertise is domain-specific a collaborative situation of their content domain should activate the experts internal collaboration scripts, while collaborative situation of another content domain should not activate the scripts. If collaborative expertise is domain-general, the difference between collaborative experts and novices should be independent from the situations' content domain.

Method

Study 1

Ten collaboration novices (six female, M=23, SD=2.4 years), social-science students from LMU Munich and ten experts (three female, M = 38.40, SD=7.32 years) volunteered for the study. To qualify as a collaborative expert one had to have worked collaboratively for the last seven years at least a mean of two hours per workday.

To standardize expertise in the content domain experts needed to have advanced at least one hierarchical level (PhD or specialist degree).

To trigger collaboration scripts through standardized collaborative situations novices and experts were shown pictures and videos as stimuli. The pictures contained collaborative situations (workshop or small group work). After introduction the investigator showed the participant one of four counter-balanced pictures for five seconds. Then the participant was asked to write down the answer to the "recall question"–What did you see on the picture? The same procedure was repeated for another picture. For the remaining pictures the participants were asked to answer three "script questions": What has most likely led to the situation? What happens in the situation? What is most likely to happen next in the situation?. The participants were given as much time as they needed to answer.

Study 2

Twenty novices (thirteen female, M=25.75, SD=4.7 years) and twenty collaboration experts (eight female, M=41.57, SD=7.87 years) volunteered for the study. All novices were medical students of LMU Munich. We investigated specialists who need a high amount of collaboration (internal medicine and anaesthesiologists).

Counter-balanced one of eight stimuli (four videos, four pictures) containing collaborative situations in medical contexts was shown to each participant for five seconds. The same procedure was repeated eight times; four times asking the recall question, and four times asking script questions, controlling for a balanced combination of stimuli type (picture/video) and question type (recall/script questions). After the eighth stimuli the participants were shown two collaborative situations of an academic setting to compare their answers to the answers out of their own content domain.

Coding scheme

For both studies the same coding scheme was developed to analyse the data. Two main categories were defined: superficial and script information. To assess detailed collaborative script information the categories of Kollar, Fischer, and Hesse (2006) were used. For example it specifies activities and roles as the important determinants in collaboration scripts. When the question is answered how this situation might continue and a person would be described as summarizing the tasks this would be coded as one activity. One investigator coded all of the transcripts and 10% of the transcripts was also coded by a student-assistant (Cohens kappa =.84).

Results

Study 1

A t-test revealed that collaboration experts ($M_{experts}$=25.20, SD=5.88) stated significantly more script information than novices ($M_{novices}$=13.80, SD=4.4), $t(18)=4.88$, $p<0.01$, $\eta^2=0.57$. As well for the recall questions a t-test revealed that collaboration experts ($M_{experts}$=5.80, SD=1.62) stated significantly more script information than novices ($M_{novices}$=2.40, SD=2.27), $t(18)=3.86$, $p<0.01$, $\eta^2=0.45$.

Study 2

A MANOVA revealed, as hypothesized the collaboration experts stated significantly more script information ($M_{experts}$=71.65, SD=33.23) than the novices ($M_{novices}$=54.25, SD=15.01), $F(1;38)=4.55$; $p<.05$; $\eta^2=.11$.Furthermore, when stimulated by videos experts ($M_{experts}$=31.60, SD=14.90) stated significantly more script-like information than novices ($M_{novices}$=22.95, SD=9.03) as revealed by the MANOVA $F(1;38)=4.93$; $p<.05$; $\eta^2=.12$. Outside the medical domain neither the difference for the picture ($M_{experts}$=5.10, SD=4.60, $M_{novices}$=5.00, SD = 4.14), nor for the videos ($M_{experts}$=6.60, SD=4.44; $M_{novices}$=4.65, SD=2.39) was significant ($F(1;38)=1.45$; n.s.).

Discussion

Experts differ regarding their knowledge of collaborative situations. Our studies are a first attempt to reliably assess experts' internal collaboration scripts. The collaborative experts draw their knowledge from their internal scripts, nonetheless which question they are asked. The difference between collaborative experts and novices disappears when confronted with situations outside their content domain. However, content domain dependency has to be further investigated in other content domains as past research has argued for domain independency of collaborative expertise (Kolodner, 2007). Further research is needed to better analyze the subcomponents of internal collaboration scripts.

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How do Students Use Socio-Emotional Markers for Self-Reflection on their Group Work in CSCL Settings? A Study with Visu: a Synchronous and Delayed Reflection Tool

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Abstract: This paper describes an exploratory study on the use of reflective markers set during synchronous collaborative learning sessions (reflection in action) for later construction of self-reflection reports upon the collaboration that occurred (reflection on action). During 2 sessions, students used the Visu tool for interaction and marker setting (positive, negative, free) and then report building on the interaction (using markers or not). A quantitative descriptive analysis has been conducted on the markers used and on the reflective categories of the sentences in the reports. Results show that students (1) paid more attention in repairing their relationship than reflecting on learning and task goals; (2) used mainly positive markers to both reflect in and on action; (3) used more their partner's markers in the second reports; (4) reflected more on themselves in the second reports to justify successes and failures, and to express satisfaction.

Introduction

In this paper, an exploratory study is reported in which students in Psychology were asked to use the Visu reflection tool in both synchronous and asynchronous Computer-Supported Collaborative Learning (CSCL) situations. Visu is a web videoconferencing platform (Bétrancourt et al., 2011) that allows participants to report their individual reflections in the form of markers (named here as reflective markers) at any time during remote synchronous collaboration. In this study, students could use two types of reflective markers: socio-emotional markers to express negative or positive feelings about the way they collaborate; and free markers to provide any other comments on the on-going activity.

It is now recognized that CSCL situations are socially and emotionally challenging, and that collaborative learning processes are influenced and shaped by emotions (Järvelä & Järvenoja, 2011). We thus consider important to provide co-learners with the opportunity to reflect on the socio-emotional aspect of collaborative action through the use of socio-emotional markers. Visu also provides students with the possibility to later review the traces of their group's work (audio/video recordings of the interactions as well as self and partner's markers). Such review can lead to – as in this study – the production of self-reflective reports.

This study is part of research investigating regulatory processes in CSCL settings. We still know little on how individuals reflect-in and on their own activities, their collaborative partners' activities as well as their group activities in joint learning tasks, although there is a growing body of research that focuses on socially shared metacognition and regulation of emotions (Järvelä & Järvenoja, 2011). Moreover, awareness information about the collaborative partners (e.g., their knowledge and emotions) is limited in CSCL settings, and one may expect that such limitation would dramatically affect the use of self- and co-regulated learning strategies. To our knowledge, there are still little awareness systems designed to support self- and shared reflection on the joint learning experience, and in particular on its social and emotional aspects in CSCL settings (Phielix et al., 2010).

This paper aims at investigating students' reflections about their collaborative learning experience after synchronous CSCL sessions. We are particularly interested in the way they used the Visu tool to individually reflect upon their collaboration after it had taken place. In this study, students were involved in two consecutive CSCL synchronous sessions, and were asked to produce a self-reflection report after each session. Our main focus is on reflection in collaborative action and on reflection on collaborative action with the help of socio-emotional markers. More specifically, our questioning is related to the use of "*reflection-in-action*" markers – that is, socio-emotional markers students and their collaborative partner did set during interaction – for later individual "*reflection-on-action*" (Schön, 1987). Students were instructed to organize their reports in 2 parts, a *retrospective* part in which they had to report their perceptions on the interaction they just had with their partner and a *prospective* part in which they had to propose ways of improving their group processes. The originality of the present study is to use Zimmerman's (2002) self-regulated learning (SRL) model as a framework to analyze student's reflection reports on their joint learning experience. Indeed, the three phases described in this SRL model fit well with the different uses of the Visu tool: use of reflective markers during the online interaction (*performance* phase) and use of interaction traces (videos and markers) in the retrospection room (*self-reflection* and *forethought* phases). In this paper, we concentrate on the use of markers for self-reflection and forethought. According to Zimmerman, in the self-reflection phase, students evaluate performance and make causal attributions for successes or failures (*judgment*). They are also supposed to react to the learning situation in different ways, by expressing different levels of satisfaction (*affective reactions*), protecting their feelings of competence (*defensive reactions*) or proposing adjustments and changes in behavior necessary to succeed (*adaptive reactions*). In the forethought phase, the aim is to define the subsequent goals and to plan the strategies to achieve them; the focus is on the task analysis, which is based on students' prior knowledge and beliefs about learning such as self-efficacy and task value beliefs (*motivation*). Our precise questioning is thus twofold: what kinds of *retrospective* (judgments, reactions) and *prospective* (task analysis, motivation) reflection processes were related to the use of socio-emotional reflective markers? To what extent do these reflection processes evolved over the two CSCL sessions in relation with the use of markers?

Visu for Synchronous and Delayed Reflection

Visu (result of ITHACA project; Bétrancourt et al., 2011) is a technology system dedicated to both synchronous and delayed reflection in computer-mediated collaboration settings. It is a web videoconferencing platform consisting of an interaction room and a retrospection room. In the interaction room (Figure 1, left), apart from other functionalities, users can leave markers on a horizontal timeline to annotate what is happening during the interaction, be it their feelings or any other types of information. To do so, they can either put a free marker by defining its content (textual form) and then hitting return (button "Poser un marqueur") or use buttons linked to predefined feeling markers: positive (green button) or negative (red button), which are empty by default (a). Text can be associated with feeling markers by using the textual form before clicking on the positive or negative button. The markers set by users are not visible by their partners during the course of collaboration (as it was thought this would affect the quality of interaction by focusing too much users' attention on their partners' markers). In Figure 1, free markers appear in black color while positive (resp. negative) markers are in green (resp. red). In the remainder of this article, we will use the terms "black", "green" and "red" markers (b).

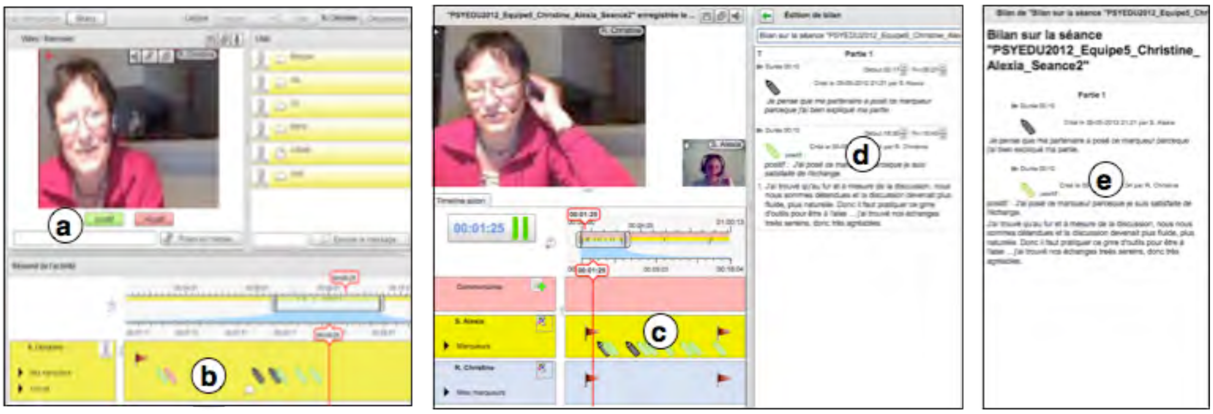

Figure 1. From left to right, the interaction room, the retrospection room and the report window in Visu.

After the interaction, users can access the retrospection room (Figure 1, middle) in their own time and review the traces of the synchronous session (videos and markers). The markers left during the interaction appear on the horizontal timeline (c) and now all the markers (the self and partner's markers) are visible for users who participated in the interaction. When reviewing the interaction, users can individually build a reflective report on the collaboration process, by using any of the markers that were set during the interaction. For this, they can either drag and drop markers in the editing space of the retrospection room and modify the text as they wish or create text blocks from scratch (d). Reports are composed of several sentences and can be visualized on a dedicated interface (Figure 1, right) that also can also present the colored markers that may have been used (e).

Study

Context, Participants and Procedure

The study took place in an ecological context, namely during the educational psychology course of the Bachelor of Science in Psychology at the Distance Learning University Switzerland. Twelve students (11 women and 1 man; students with very different professional backgrounds; mean age 33 years) participated in this course in the 2011-2012 academic year. The study was carried out during a three-week online classroom period dedicated to the constructivism/socio-constructivism topic. In this period, students were asked to work in dyads (5 same-gender dyads and 1 mixed gender dyad) and used the Visu platform during two synchronous CSCL sessions; the 1st session was held during the 1st week of Period 4, the 2nd session during the 2nd week. During these CSCL sessions, students were invited to discuss and share their understanding about four introductory texts on Piaget's and Vygotsky's theories of learning (two "Piaget" texts and two "Vygotsky" texts). A CSCL script, inspired from a Jigsaw (macro) script, was used to organize both CSCL sessions. This script was designed so that each member of the dyad was invited to individually read a complementary text in preparation for both sessions: student 1 read the "Piaget" Text 1 (for Session 1) and the "Vygotsky" Text 2 (for Session 2); student 2 read the "Piaget" Text 2 (for Session 2) and the "Vygotsky" Text 1 (for Session 1). Each student had to explain his/her text to his/her partner during each synchronous session. Both students then had to (orally) answer together comprehension questions. After each CSCL session, students were asked to use Visu (including the markers) to build individual reflective reports on the interaction with their peer. The report had to be composed of two parts, a *retrospective* part and a *prospective* part. For this task, students were provided with the following instructions: "In the retrospective part, we ask you to express your personal perception on how your partner and yourself have collaborated. This part should concern your own activity, your partner' activity as well as the work of your team. In the prospective part, you have to think about how to improve your team's work, in particular, your collaborative strategies and the quality of the relationship with your partner".

Research Questions

As already said, we decided to use an exploratory approach as we still know little about the use of "reflection-in-action" markers (markers set by learning partners during interaction) for reflection-on-action (reflection after the collaboration session) in CSCL settings. In line with the objectives previously described in the introduction, we will answer the following questions: Q1: What kinds of reflection processes were involved when reviewing the interaction with the learning partner? Q2: What kinds of personal and partner's markers (socio-emotional markers – negative/red and positive/green markers – and free/black markers) did the students use in their reflective reports? Q3: What kinds of reflection processes were related to the use of reflective markers? Q4: How did reflection processes in relation with the use of markers evolve over the two CSCL sessions? Towards whom (themselves, their partner or their group) were reflection processes oriented in both reflective reports?

Analysis Methodology

To answer these questions, we conducted a quantitative descriptive analysis given that the number of dyads was relatively small (N = 6) due to the fact that the study took place in an ecological context (a distance learning course). The analysis was performed on the following measures:

1. The number and type of reflective markers (red/negative, green/positive and black/free) set during both synchronous CSCL sessions (Sessions 1 and 2).
2. The number of reflective markers used in both reflective reports (Report 1 after Session 1, Report 2 after Session 2) depending on (a) their author (personal/self markers and partner's markers), (b) their type (red, green and black) and (c) the reflection category to which they were related. These categories were defined based on Zimmermann's (2002) model. We distinguished between two main categories. The first one refers to the *reflection* phase: evaluation, causal attribution (judgment categories), satisfaction/affect, and adaptive/defensive (reaction categories). The other one refers to the *forethought* phase: goal setting, strategic planning (task analysis categories), efficacy, outcome expectations, intrinsic value, and learning goal orientation (motivation).

Results and Discussion

With respect to Question 1, we were able to classify quite all the sentences in both reports according to the categories of Zimmerman's (2002) SRL model. These sentences mainly referred to the reflection phase (69%), with a higher percentage for the judgment categories (47%) than for the reaction categories (22%). Only 18% of the sentences referred to the forethought phase, with an equal proportion (9%) for the task analysis categories and the motivation categories. Fifteen percent of the sentences were classified as "other", and mainly described technical problems that occurred during the CSCL sessions. It is noteworthy that almost half of the sentences in both reports (45%) were associated with a marker. Linked-marker sentences were mainly dedicated to reflection (88% against 2% to forethought), mainly to express evaluation (38%), causal attribution (25%) and satisfaction (25%). These results suggest that the students' reflection process took a conservative rather than progressive direction. Reflection seemed to be a "looking-backward" process by which students used reflective markers to mainly react upon what was right or wrong in their interaction with their partner. The lack of looking forward led them to pay less attention in reflecting on the subsequent goals and how to achieve them.

With respect to Question 2, results showed that the majority of markers used in both reports was found to be socio-emotional (85% of 151 markers); that was also the case during interaction sessions (71% of 129 markers in Session 1; 66% of 74 markers in Session 2). The highest percentage of linked-marker sentences in both reports was related to positive (green) markers (53%) followed by free (black) markers (32%), the lowest being for negative (red) markers (15%). This result is quite similar to what was observed for interaction sessions (55% of positive markers in Session 1; 56% in Session 2). Finally, we found that students used more frequently their own markers (68%) than their partner's markers (32%) in the reports, the highest percentage being for self-positive markers and the lowest for partner-negative markers. These results suggest that students preferentially used socio-emotional markers (in particular positive markers) for reflection in- and on action. They also preferred using their own reflective markers to express positive feelings on the collaborative experience.

Regarding Question 3, as already said, markers used in both reflective reports were linked to sentences that focused mainly on reflection on the past experience. Self-reflection sentences that were associated with markers referred more to judgment processes (evaluation: 38% and causal attribution: 25%) than to reaction processes (27%). Moreover, students used mainly positive markers to make evaluation (24%) as well as to react and express their satisfaction (18%). Evaluation was accomplished through the use of mainly self-positive markers (21%), whereas self-positive markers (9%) and partner-positive markers (9%) were used equally to express satisfaction. Causal attribution sentences were associated with mainly free markers (12%), with a nearly equal percentage of self-free makers (7%) and partner-free (5%) markers. Therefore, results suggest that students preferentially used socio-emotional markers –in particular positive markers– to evaluate and react to the past collaborative learning situation. They preferred using "non-emotional" markers to make causal attributions for successes and failures. Moreover, they used mainly their own markers to give positive evaluation, whereas they used their partner's markers when expressing satisfaction or causal attributions.

With respect to Question 4, results related to the collaboration sessions showed a decrease in the use of negative markers (-5.8%) and an increase in the use of free markers (+5.2%) between the two sessions. We suppose that after the construction of their first reflective report, students were more conscious of the fact that their partner could see (and also use) their markers, and might have not want to hurt them. Concerning the reflection processes, there was a shift from partner- and group-focus to self-focus between both reflective reports. In fact, the highest percentage of linked-marker sentences in Report 1 was focused on the group (25%) followed by an equal percentage of self- and partner-focused sentences (19%). In Report 2, the highest percentage was for self-focused sentences (34%) followed by an equal percentage of sentences focused on the partner and the group (21%). Partner- and group-focused sentences mainly consisted of "evaluation" sentences in both Reports 1 and 2. Concerning self-focused sentences, the highest percentage was for "causal attribution" sentences in Report 1, and for both "causal attribution" (+7%) and "satisfaction" (+5%) sentences in Report 2. Meanwhile, the sentences in Report 2 were more linked to the partner's markers (+18%) and less to one's own (-10%). This suggests that the students integrated more their partner in their own reflection-on-action, especially to justify their successes and failures and to express their satisfaction.

As a conclusion, we presented Visu, an innovative tool dedicated to both synchronous and delayed reflection in CSCL settings. To our knowledge this tool is quite unique, as there are little awareness systems that support both reflection in collaborative action and reflection on collaborative action. That is why we adopted an exploratory approach to study the use of markers set by learning partners during interaction to reflect after the collaboration session. To sum up the main results, it appears that the students (1) paid more attention in repairing their relationship than reflecting on the learning and task goals; (2) used mainly positive markers both to reflect in- and on collaborative action; (3) used more their partners' positive markers in their second reflective report; (4) reflected more on themselves in the second report to justify themselves and to express their satisfaction. The relatively small sample size is a limitation of this study; we however consider this study an innovative contribution to the line of CSCL research that we will complete with a qualitative description of detailed processes. More precisely, the last two results of the study appear very interesting, letting us think that a kind of dialog is being set up between the two partners in the second reflective report. We can suppose that a socially shared regulation process did emerge in the second self-reflective report, since the students seem to have self-reflected on collaborative action using the markers put in action by their learning partner. Future work will focus on this assumption, by analyzing in more details the contents of the markers in relation to the contents of the sentences, and by focusing on the behavior of the students within each dyad.

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Designing Learning Environments for Knowledge Building: Inquiry Discourse of Chinese Tertiary Classes

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Abstract: This study examined the effects of two designed learning environments for knowledge building. Two groups of first year Chinese tertiary students learning business English were engaged in a strong form of a knowledge-building environment (Principle-based Learning Environment, PBLE) and a weak form of knowledge-building environment (Knowledge Forum Learning Environment, KFLE), respectively. Inquiry thread analysis of the online discourse suggested PBLE students were more able to self-initiate goals for inquiry, improve ideas, and achieve toward deeper collective knowledge advances. The design issues including the importance and manifestation of knowledge building principles are discussed.

Introduction and Background

CSCL studies involving educational interventions are expected to provide information on how a learning environment is created, what effects it brings about, and explanation of factors contributing to success or failure. A striking feature of design research is to design effective learning environments with principles. Knowledge building (Scardamalia and Bereiter, 2006) focuses on creation of new knowledge, representing one of the key examples for educational innovation. Scardamalia (2002) proposed 12 knowledge building principles for the knowledge building community. However, as the principles are usually not sufficiently detailed to determine every design decision (Edelson, 2002, p. 106), teachers may find it hard to transform the principles into classroom practices. For example, the principles are intertwined and may appear unclear and vague in terms of social practices (Hakkarainen, 2009); Chan's project (2011), the Hong Kong Knowledge Building Teacher Network revealed that there were many false starts and surface understanding of principles. Even though ample evidence has been collected to delineate the successful implementation of knowledge building approach in schools (Lee et. al., 2006; van Aalst, 2009; Zhang et. al., 2007; 2009), knowledge building still poses great challenges and demands on teachers (Zhang, 2009). Therefore, more examples illuminating knowledge building classroom and online practices informed by knowledge building principles are needed. This study intends to describe a case of designing environments for knowledge building in higher education setting and address one research question: what are the differences on student discourse between an innovative, principle-based knowledge building environment (PBLE) and a less innovative, only technology (in this case, Knowledge Forum) supported learning environment (KFLE), and how are they manifested?

Method

Two classes (n=60) of first year university students learning business English in a Sino-British Educational Program in Mainland China participated in the study. In view of the innovative nature of knowledge building (*like the Copernican Revolution, profoundly different from even the best of traditional and modern classrooms,* Scardamalia, 2002, p.77), and the didactic past instructional experience of the Mainland Chinese students, we adopted a quasi-experimental design in which Group 1 (n=30) was exposed to a strong principle supported knowledge building learning environment (PBLE) and Group 2 (n=30) was exposed to a weak, KF technology supported learning environment (KFLE); KFLE is less innovative, but still a leap from traditional classroom because technology was used to support learning and communication. We argue such a design is appropriate to identify to what extent an innovative educational model can be accepted by the students who are new to collaborative knowledge building.

Both classes were taught by the same teacher in a two-semester course, entitled "*Introduction to Business*", which is a franchised course from the Sino-British program, aiming to strengthen students' business knowledge as well as communicative and critical thinking skills. Each semester consisted of 14 weeks, with two consecutive lessons (1.5 hours) per week. In both classes, students followed the same curriculum: learning business concepts, holding discussions and doing group work (projects). After class, they wrote notes on Knowledge Forum (KF), which is a computer-supported platform for collaborative learning. While KF is considered an integral part of knowledge building, we employed it for both PBLE and KFLE. To design and differentiate the PBLE and the KFLE, we focused on three key dimensions of curriculum, engagement, and reflection in particular premising on three KB principles: *improvable ideas*, *community knowledge and collective, reflective assessment.* (1) We implemented *inquiry-based* course curriculum (case studies, authentic questions, etc.) for both environments and students tried to answer questions and raised their own questions as well. However, in alignment with the knowledge building principle of *improvable ideas*, PBLE students were explicitly scaffolded to focus on ideas. They were not only asked to make their own ideas public on KF, but were encouraged to work with those ideas. They posited an idea has a life; and sufficient time was allowed for them to nurture ideas; elaborate, refine, and revise those ideas; and track the evolution path of them. KFLE students, as typical for tertiary courses, also focused on getting good ideas but they tended to miss out the notion that ideas are objects that are improvable.(2) For engagement, both groups were encouraged to participate actively; specifically, PBLE students were acculturated into a *community ethos* and regarding KF as the public space for idea improvement. They were encouraged to take on *collective responsibility* to build on each other, to improve their initial understanding, and to solve problems in the common goal of advancing collective knowledge. KFLE students were required to answer teacher questions and individual effort was much appreciated. (3) All students were involved in reflective presentations, with PBLE focusing on *meta-discourse* and KFLE on task-accomplishment. From Week 3 to Week 9, an 8-minute or so presentation was conducted by selected student at the beginning of each lesson. For PBLE students, reflection as a way of *concurrent, transformative assessment*, helps them think about what they have learnt, conceive of the connections between new and prior knowledge, and set possible new goals for inquiry. KFLE student were not informed by knowledge building principles and might present in class his/her view of how a task has been completed or how a problem has been solved, without deliberately identifying the knowledge gaps.

Data Sources and Results

Before the study, we obtained the National Matriculation Test scores of the students and an independent sample *t*-test showed there was no significant statistical difference in terms of the students' baseline abilities, $t(58)=.50$, $p=.62$. To compare the discourse process of the designed environments, we included students' forum notes and classified them into inquiry threads. An inquiry thread was defined as a cluster of notes addressing the same principle topic or problem in the communal space (Zhang et al., 2007). Thread analysis has been widely used to help characterize knowledge building dynamics and track collective knowledge growth.

Student forum discourse during semester one focused on a core theme "Business Environment". Six *views* (online note-writing space) were established, namely "What is business?", "Egg theory", "Political environment", "Economic environment", "Social Environment" and "Technological Environment". In these views, PBLE students wrote a total of 919 notes, and KFLE students 472 notes; apparently, PBLE students were more productive in note creation. To further investigate knowledge building dynamics, we coded all KF notes into inquiry threads. This iterative process resulted in identification of 51 and 30 threads in PBLE and KFLE respectively. Inquiry thread maps (omitted for space consideration) were drawn subsequently to indicate how many notes were created around a thematic topic, how many students were involved in the discussion, how long the discussion lasted, and the interconnections among the threads (similar to Zhang et al., 2007). However, unlike students immersed in knowledge building for a long period of time and able to initiate all inquiry threads (Zhang et al., 2009), the students in this study were new to knowledge building and the teacher adopted a more eclectic instructional design. He pre-specified some inquiry themes in line with the curriculum topics and, simultaneously encouraged emergent, student self-defined trajectories of inquiry, which were particularly emphasized in PBLE. As a result, 60.8% (31 of 51) of the inquiry threads in PBLE were self-initiated by the students and only 26.7% (8 of 30) in KFLE were self-initiated by students. The other inquiry threads were started by the teacher.

To examine the deepening moves of discourse in the inquiry threads, we analyzed the threads informed by four knowledge building principles: use *of authoritative information, improvable ideas, idea diversity, and epistemic agency*. Based on KB literature and thorough reviews of all the inquiry threads, we developed a coding scheme with different categories and levels indicating the quality of the inquiry discourse (Table 1).

Table1: The coding scheme for the inquiry threads

Category	Level	Description
Use of authoritative information	1	Limited indication of use of information; or simply refer to a web link or suggest sources; information is not pertinent to the issue in question
	2	Indicate relevant sources; copy and paste information, relevant but lack of understanding and digestion
	3	Contribute authoritative information in a digested and constructive manner; use referenced notes; use information to improve theories
Improvable ideas	1	Most of the ideas are scattered, fragmented, and unfocused; claims and assertions from students' common sense
	2	Quite a number of build-on discourses, with examples, investigations, or meaningful information to support and show understanding of a business topic, situation, phenomenon, case, etc
	3	Discourse indicating inquiry developed in a deepening way, forming coherent, refined views on business concepts, situations, phenomena, etc; revision of or improvement on theories and models
Idea diversity	1	Simply show disagreement or being cynical without providing sufficient reasons
	2	Provide some other lens to questions or problems, with good reasons backing up argument, hypothesis, conjectures, etc
	3	Discern critically both aspects of the phenomena, situations or business cases; use another theory to explain, forming a holistic view on existing theories and models
Epistemic agency	1	Ask factual, information-seeking questions; mostly general description, not negotiation of ideas between participants
	2	Show doubt, confusion, puzzlement and seek clarification and better understanding of a business situation, phenomenon, case, concept, etc
	3	Set goals for inquiry; meta-cognitive; review and monitor group discourse development; evaluate and summarize; compare different models; meta-discourse

One rater coded all the threads; a second rater coded 30% of the threads, with an inter-rater reliability of.83 (Pearson's correlation coefficient). The mean scores and standard deviations of each KB-principle category are shown in Table 2. Multivariate analyses conducted indicating significant results following by univariate analyses. Significant differences were obtained for Epistemic Agency, $F(1, 79) = 11.0$, $p<.01$; marginal significance for Use of Authoritative Information, $F(1, 79) = 3.9$, $p=.053$; and Improbable Ideas, $F(1, 79) = 3.7$, $p=.058$; while no significant difference was found for Idea Diversity $F(1, 79) = 1.4$, $p=.24$. These results suggest that the PBLE class was more able to ask questions and seek explanations, set forth ideas and theories, and be committed to sustained knowledge advancement with support of outer resources.

Table 2: Comparison of knowledge building discourse between PBLE and TELE

	Use of Authoritative Info.	Improvable Ideas	Idea Diversity	Epistemic Agency
PBLE (n=51) M(SD)	1.6 (.14)	2.0 (.10)	1.4 (.14)	1.8 (.09)
TELE (n=30) M(SD)	1.2 (.19)	1.7 (.13)	1.2 (.18)	1.3 (.12)

To obtain an overall picture of forum discourse, we conducted factor analysis for the 4 items of KB-principle, which led to one factor structure (we call knowledge building discourse) with 71.6% of the variance explained. We then classified inquiry threads into three phases depending on the date of the last written note in a thread, namely Phase 1(Week 1 to 4), Phase 2 (between Week 4 and 8) and Phase 3 (beyond Week 8). As a result, PBLE produced 10, 25, and 16 threads during Phase 1, 2 and 3 respectively; and KFLE created 6, 13, and 11 threads. A 2 (Environment)×3 (Discourse Phase) ANOVA was performed to assess whether knowledge building discourse could be predicted from learning environment (PBLE vs. KFLE), phases of discourse (Phase 1, 2 and 3), and the interaction between these two factors. This analysis of variance revealed a significant main effect for discourse phases, $F\ (2, 75) = 9.2,\ p<.001,\ \eta^2=.20;$ for environments as well, $F\ (1, 75)$ = 6.0, $p<.05$, η^2=.07; but no significant interaction effect, $F\ (2, 75) = .38,\ p= .68,\ \eta^2=.01$. Figure 1 shows the mean scores of knowledge building discourse across three discourse phases in two learning environments.

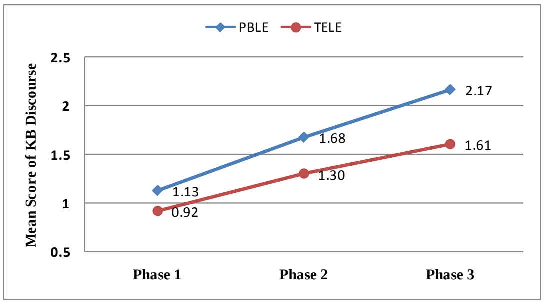

Figure 1. Mean scores of knowledge building discourse across three phases

Conclusion

With the PBLE and KFLE design, both classes were engaged in inquiry and discussion (generating 919 and 472 notes respectively) and improved the quality of their discourse over time (see Figure 1), which is a sharp contrast to and far better than (we argue) the usual teaching environment, characterized by teacher as the sage on stage and limited teacher-student/student-student communication. Inquiry thread analyses indicated that PBLE students demonstrated much more agency for inquiry, used information more constructively, and refined ideas more sustainably than their counterparts in KFLE, which on one hand, removed our fear that whether Mainland Chinese students could accept and adapt to such an innovative notion of knowledge building; on the other hand, shed light on the importance of knowledge building principles in the design process. This study demonstrates how instructional design can be aligned with knowledge building principles. Thread analyses also suggest some principles, such as epistemic agency, could be manifested saliently after the instruction, while others such as idea diversity might not appear so salient.

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Facilitating belief change via computer-supported collaborative knowledge-building

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Abstract: In this study, we investigated prospective teacher-education students' belief change in a CSCL environment enabled by knowledge building pedagogy. Data mainly came from a belief survey and students' online discussion. The results indicated that engaging students in collaborative work with knowledge was conducive to making their teaching beliefs become more student-centered.

Introduction

Quality teaching is essential to effective education and is deeply influenced by teachers' teaching beliefs (Clark & Peterson, 1986; Pajares, 1992; Richardson, Anders, Tidwell & Lloyd, 1991; Stuart & Thurlow, 2000; Wilson, 1990). Teaching beliefs, however, are difficult to change and are shaped by one's past learning experiences (Entwistle, Skinner, Entwistle, & Orr, 2000; Nespor, 1987; Rath, 2001; Schaefer & Zygmont, 2003; Stuart & Thurlow, 2000). Thus, during the stage of teacher education, it is essential to examine teacher-education students' teaching-related beliefs, and more importantly to help them develop more informed and diversified teaching beliefs. To help teacher-education students reflect on their own teaching beliefs while experiencing other possible kinds of teaching beliefs, this study developed a knowledge building environment that focused on sustained production and improvement of ideas of value in a community (Scardamalia & Bereiter, 2003)—i.e., Knowledge Forum, a computer-supported collaborative knowledge–building environment. It is posited that learning in a more socio-constructivist manner would provide teacher-education students with more opportunities to collectively reflect on teaching beliefs and eventually construct more informed teaching beliefs.

Method

Participants (N=28) were teacher-education students taking a course about science teaching. The course was 18 weeks long and aimed to help students develop more informed teaching beliefs and practices regarding student-centered and constructivist-oriented teaching beliefs and practices. Previous studies showed that teacher-education student's teaching beliefs were more teacher-oriented and less informed. The instructional design was based on knowledge building pedagogy, with Knowledge Forum (KF) being employed to complement knowledge building via sustained idea improvement. All students' ideas and discussion related to improving teaching practice were recorded in a KF database. To make the course more efficient within limited time span, in the beginning of the course, students were paired and were required to practice their teaching (i.e., to co-teach) twice—therefore, there was 28 times of practices in total, with practices 1-14 being referred to as the first phase, and practices 15-28 as the second phase. During their practices, students were guided by knowledge building pedagogy to discuss and reflect on their teaching online in KF. Both the instructor and students worked as community members. In particular, the instructor served as a facilitator to engage students in online discussion and to improve their teaching practice. Everyone could freely propose questions and comments in KF for deep discussion and reflection. Data mainly came from a pre-post belief survey and online posting in KF as described below:

1. Analysis of the belief survey. The belief survey contains the following questions which were adapted from Tsai's (2002) study with only minor text revision to suit for this study: (a) What do you think is an ideal way to teaching science, and why? (b) What do you think are the key factors to ensure successful science teaching, and why? (c) What constitutes an ideal science teacher, and why? (d) What do you think is an ideal way to learn science, and why? (e) What do you think are the key factors to ensure successful science learning, and why? (f) What does an ideal science learning environment meant to you, and why? The survey data were analyzed using a pre-determined coding scheme (see Table 1). Using 50% of this data, the inter-rater reliability (kappa coefficient) were computed to be 0.92 (p<.01).

Table 1. Coding Scheme of teaching beliefs

Category	Example
Teacher-centered teaching beliefs	"[Teachers should provide] complete laboratory materials and various equipments".
	"[Teachers should] transfer basic knowledge, by giving lectures and helping students establish knowledge base".

	"Teaching through demonstration and experiment is important."
Student-centered teaching beliefs	"Open and comfortable environment."
	"Respond to students' differences and needs by using suitable teaching pedagogy".
	"Stimulate learning motivation and curiosity".

2. Analysis on online posting (with a focus on learning processes). Online posting was analyzed via multiple ways. First, we analyzed student participation patterns by employing descriptive analysis (e.g., number of notes contributed, number of notes read, and number of notes built-on). Second, we analyzed the function and quality of feedback for the two phases of teaching practices. In terms of function of feedback, we adopted the same coding scheme used for the above survey to code teaching beliefs, including feedback for improving "teacher-centered" teaching practice and feedback for improving "student-centered" practice (see Table 2). Using notes as units of analysis, the inter-rater reliability of this coding was computed to be 0.94 ($p<.01$) (using using 50% of this data and kappa reliability coefficient). In terms of the quality of feedback, we employed the coding scheme by Dempsey, Driscoll, and Swindell (1993) which contains four evaluative categories, including "no feedback", "simple verification feedback", "specific feedback" and "elaborated feedback", with the latter ones representing better quality feedback (see Table 3 for rating procedure). This analysis used sentences as units of analysis, the inter-coder reliability (using 50% of the data and Spearman correlation) was computed to be 0.91 ($p<.01$). Pair-sample t-test was performed to examine whether there were any significant differences in terms of both the function and quality of feedback between the two different phases of teaching practice.

Table 2: Definition of each coding category regarding function of feedback posted on Knowledge Forum

Category	Examples of student answers
Teacher-centered	The two teachers' classroom management was good, and the managing processes also went well, too.(s11) If I were you, I would explain the purpose and principles of this experiment first. Then, I would explain the process of the experiment, and after that, try it out. (s09)
Student-centered	The designed content of the lesson was inviting, which increased the interaction between students and the teacher really well, and also made the students to think more actively. (s14) After finishing the learning activities using learning sheet, the teacher and the whole class should go through the questions again and rethink about the activity, to give the students time to reflect on what they did and ideas they generated based on their observation; this is great! (s15)

Note: The " s + number " represents a particular student in the class.

Table 3: Coding scheme regarding quality of feedback posted online in Knowledge Forum

Category	Definition	Examples from the answers of student teachers
No Feedback	Presents a question and requires a response, but does not indicate whether the response is good.	Magnets are marvelous things, they make me think of the magnet board and fishing game I played with when I was in elementary school. (s22)
Simple verification Feedback	Simply informs the learner of a "good" or "bad" response.	The teaching tempo is really good, such as the time management and classroom management; everything was good! (s13)
Specific Feedback	Informs the learner what the good response should be.	You can ask students more questions before explaining. Sometimes you forget to give the students feedback. (s06)
Elaborated Feedback	Provides an explanation for why the learner's response is good or bad or allows the learner to review materials relevant to the attributes of a good response.	After the explanation, you can let the students identify the bugs on the stage; this way, you can both facilitate some interactions, and get to know better if they can really identify the categories of bugs or not. (s15)

Results

1. Belief change as learning outcome

As Table 4 shows, it was found that the score of participants' teacher-centered beliefs dropped significantly after the semester. At the same time, the participants' student-centered beliefs significantly raised after the semester.

Table 4: belief change assessed in the beginning and at the end of the semester

Category	Pre-test		Post-test		t-value
	M	SD	M	SD	
Teacher-centered	1.08	1.35	0.46	0.76	2.54*
Student-centered	5.15	2.49	8.00	3.26	-4.58**

*p<.05 **p<.01

2. Learning processes: Online KF activities

Pre-post comparisons were made between two phases of teaching practice (9 weeks for each phase) in terms of basic online KB activities/measures (see Table 5). Overall, the findings suggest that the time and effort spent on collaborative learning and discussion in KF were progressively increasing over time. Figure 1 showed that students' built-on links on KF. There was a lot of feedback and suggestions made for each teaching practice as shown in each note cluster (the arrow signals who provided feedback to whom), indicating that students were reading and sharing ideas for improving teaching frequently.

Table 5: Profiles of participants' online performance

	Phase 1		Phase 2		t-value
	M	SD	M	SD	
1. # of notes created (contribution)	11.39	4.69	13.81	5.13	-2.38*
2. # of notes read (community awareness)	124.39	69.56	187.18	137.33	-2.75*
3. # of notes built on (collaboration)	9.75	4.38	12.93	4.60	-3.29**

*p<.05 **p<.01

3. Learning processes: function and quality of feedback

First, in terms of the function of feedback, as Figure 2 shows, it was found that feedback given to enhance "teacher-centered" beliefs decreased while feedback given to enhance "student-centered" beliefs increased. The result of t-tests showed that there was a significant decrease from the first phase of teaching practice (Practices 1-14) to the second phase of teaching practice (Practices 15-28) in terms of "teacher-centered" beliefs (M=6.11, SD=2.78, for 1st phase; M=3.71, SD=2.24, for 2nd phase; t=4.62, p<.01), while there was a significant increase in terms of the feedback provided to enhance "student-centered" beliefs (M=5.07, SD=3.11, for 1st phase; M=7.25, SD=2.77, for 2nd phase; t=-4.52, p<.01).

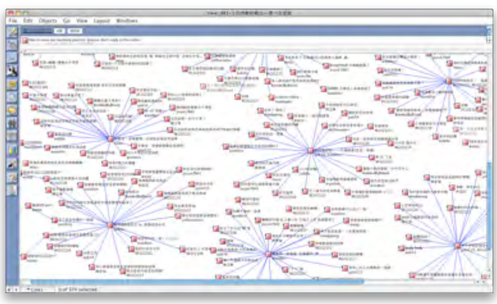

Figure1. Students' collaborative built-on links in a KF view (i.e. a discussion board).

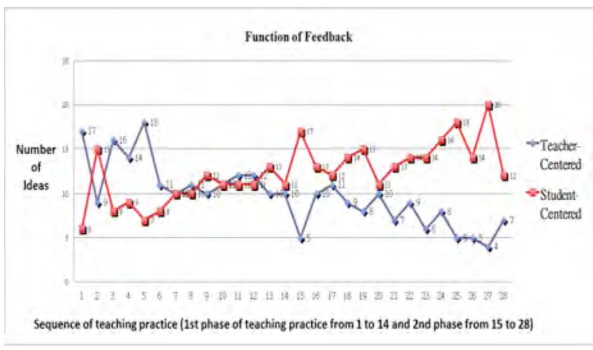

Figure 2. Function of feedback: To improve teacher-centered or student-centered teaching

Moreover, it was found that in terms of quality of feedback, there was a significant change in terms of how the quality of feedback changed in the 28 individual teaching practices (14 each for the first, and second, phase of the teaching practice). The results of t-tests (see Table 6) indicate that better quality feedback (e.g., elaborated feedback) contributed by teacher-education students progressively increased over time, while the lower quality feedback (such as no feedback or simple verification feedback) gradually decreased over time.

Table 6. T-test results regarding quality of feedback between two phases of teaching practices

	First Phase		Second Phase		t-value
	M	*SD*	*M*	*SD*	
No feedback	0.05	0.05	0.03	0.03	2.15*
Simple verification feedback	0.30	0.08	0.23	0.09	4.07**
Specific feedback	0.29	0.09	0.26	0.09	1.49
Elaborated feedback	0.36	0.11	0.44	0.14	-3.82**

*p<.05 **p<.01

Conclusion

To sum up, the instructional design in this study is based on knowledge building pedagogy. Each participating teacher-education student was required to practice his or her teaching twice. After practice, they collectively reflected on their teaching beliefs and practice to better understand more diversified possibilities of teaching and learning approaches. During the process of teaching practice, participants provided teaching feedback online in KF for discussion and systematically integrated their feedback into their instructional design for their second teaching practice. By discovering and solving related problems occurred during their first teaching practice, students were able to improve their teaching ideas/practices by re-designing their instruction. The results showed that after working continuously to generate, build on, and improve their ideas and practices, the teacher education students could generate more elaborated feedbacks and ideas about teaching, and those feedback/ideas tended to support more student-centered beliefs. In addition, the results of the pre-post belief survey also suggested that the participants' teaching beliefs shifted from teacher-centered to student-centered ones. The findings confirm previous research in that it is possible to help students transform their beliefs by engaging them in computer-supported collaborative knowledge building environment/community (Chang & Hong, 2011; Hong & Lin, 2010). Further studies will be conducted in order to better understand the process of belief change for teacher-education students.

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Group Cognition As Multimodal Discourse

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Abstract: Group cognition has been instrumental in the development of CSCL, thus further understanding its nature becomes necessary to sustain growth in the field.. In this paper, following Sfard's conception of thinking as communicating, we study group cognition from the perspective of discourse. We go beyond the more traditional stance on discourse by focusing not only on the verbal modes of communication, but also on nonverbal modes, including gesture, static image, and dynamic visualization. Specifically, we use the mathematical discourse of a group of preservice teachers, who are solving problems collaboratively with the support of a dynamic geometry environment, to illustrate the multimodal nature of group cognition.

Introduction

Our study is motivated by the need to better understand group cognition (Stahl, 2006) in order to ultimately promote collaborative knowledge building in computer-supported learning environments. Indeed, group cognition is not the sum of group members' cognition and cannot be decomposed into individual group members' cognition (Stahl, 2006). Instead, group communication itself should be the core of analysis for studying group learning for two reasons. First, according to Sfard (2008), thinking is a predominantly discursive. Second, group collaborative problem solving is accomplished no only by the interactions among group members but also by the interactions between group members and the learning environment. The focus of much research in the field of CSCL has tended to be solely on the verbal modes of communication (i.e., speech and writing). Such research provided insights in observing and interpreting verbal and written communication in collaborative learning. However, it did not take into consideration other modes such as gesture, image, and dynamic simulation. Indeed, communication in a group is a complex process mediated by multiple modalities if not simultaneous. Consequently, in this paper, we take into consideration multiple modes of communication to analyze the mathematical discourse of a group of secondary preservice teachers (PSTs) as they are solving problems collaboratively with the support of a dynamic geometry environment. The focus of the paper is how group collaborative observation and conjecturing is mediated by various communicative modes (Kress, 2001).

Context, Participants and Data Sources

Data was drawn from a teaching experiment (Steffe & Thompson, 2000) conducted in a large mid-west university. A unit about geometric transformations was designed for a geometry content course for secondary preservice teachers. One of the overarching goals of the unit is to develop the idea of geometric transformation as function or mapping taking points on the plane to points on the plane (Hollebrands, 2003). Fifteen PSTs enrolled in the course participated in research. Two groups of four PSTs were randomly selected from all the participants as focus groups. All eight PSTs in the focus groups were interviewed individually before and after the geometric transformations unit. Each focus group's class interactions were videotaped. PSTs' artifacts, including, notebook, worksheets, and screen records of computer activities, were collected. The episode we present here is from the first class of the unit. Prior to this activity, PSTs reviewed four types of geometric transformations (i.e., reflection, rotation, translation, dilation). With the support of the dynamic geometry environment, PSTs were examining the effect of the two functions with exact same rule but different domain:

Function 1: $f(x, y)=(x+y, x-y)$, where $(x, y) \in x^2+y^2=4$;

Function 2: $f(x, y)=(x+y, x-y)$, where $(x, y) \in R^2$.

The goals of the entire activity with 18 functions include: 1) elicit PSTs' misconceptions of geometric transformations, for example, two similar shapes means dilation; 2) help PSTs attend to the relationship between preimage and its correspondent points; 3) help PSTs understand the role of domain in defining geometric transformations. The episode we present is from one of the focus groups, which comprised of four PSTs: PST 1, PST 2, PST 3, PST 4. They were sitting in a hexagon shape table with one computer installed with dynamic geometry software, as it is show in Figure 1. A worksheet with the steps of constructing circle and preimage and image of the functions is available to each PST.

Figure 1. PSTs explore geometric transformations.

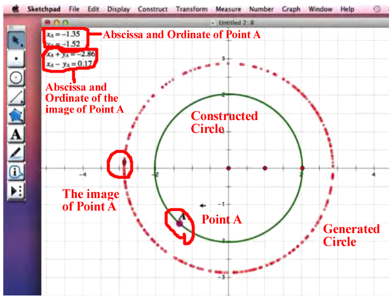


Figure 2. Screen shot of Function 1

Analysis

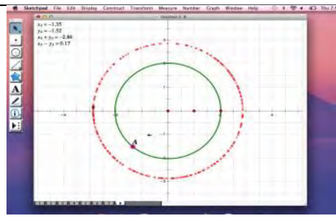
Since our aim is to illustrate the multimodal nature of group cognition in the aforementioned context, we focused our analysis on multiple communicative modes in collaborative group observation and conjecturing. To do this, we transcribed the video taking into account speech, actions and visual mediators, and arranged them by a combination of verbal turn-taking and action given that speech and action might not occur simultaneously. This way of defining turn-taking stands in contrast to the more commonly way of defining turns in which the main mode is speech and actions and mediators are attached to the turn as defied by speech. In doing so, we would be able to make explicit the use of multiple modes as they happened in the group communication. Our analysis focuses on what modes are utilized by the group in the collaborative observation and conjecturing activity.

Results

Here, we present two experts to illustrate how group collaborative observation and conjecturing can be conceptualized as multimodal communication. The first illustrates how the group's observations were accomplished by various modes namely, speech, static images and dynamic visualizations. The second shows how the group's conjectures were mediated by speech, gesture, and static images and dynamic visualizations. Moreover, we describe to what extent and how multiple modes shaped the group's thinking about geometric transformations

Excerpt 1: Collaborative observation mediated by speech, static image and dynamic visualization

Table 1: Transcript of examining the effect of Function 1.

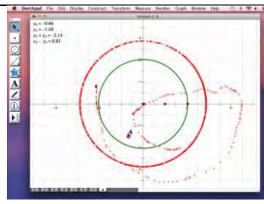
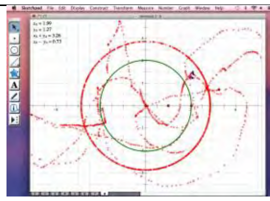
Time	Speech	Action	Visual Mediator
[00:05]		PST 4 is constructing a circle with radius of 2.	
…			
[00:36]	PST 4: there goes a circle, there goes a circle.	PST 4 used the touchpad to move preimage point A around the constructed circle.	 Figure. 3 Screen shot of the preimage and image of Function 1
[00:41]	PST 2: on the circle, they are all changed.		
[00:47]	PST 1: On the circle, Yes, everything changed.		
[00:51]	It appears to be dilation by [inaudible] degree.	PST 4 used the touchpad to move the curse onto the menu, and got ready for the next task.	
…			
[01:21]	PST 1: it is an even dilation.		

At the beginning, PST 4 performed a series of drawing actions. Following the given directions, PST 4 constructed a circle of radius 2 as the pre-image and defined point A on it. Then, she constructed the image of point A. After the constructions, she moved the point A on the circle. As point A was moving around the circle, a circle of radius larger than 2 emerged from the trace of the image of point A (Figure 3). PST 4 observed that the emerging figure on the screen was a circle. Her observation then becomes a shared group observation for two reasons: first, her speech and the momentary static image of the circle generated were made public at the small group; second, the observation was taken up by PST 2, as he pointed out that the all the points on the constructed circle were changed to the generated circle. PST 2's observation soon became a shared group observation for that the momentary static image of the circle was public and was accepted by PST 1. Based on the group collaborative observations of the dynamic visualization, PST 1 conjectured that the momentary static image appeared to be dilation. Again, this conjecture was accepted and refined by PST 1 based on her observation of the image on the screen.

In sum, we have shown that group observation and group conjecturing are not only mediated by the speech from group members, but also the dynamic visualization and the momentary static images. A multimodal analysis of the data let us conclude that two similar circles as shown in Figure 4 is a realization (Sfard, 2008) of the mathematical object of dilation in this group. Moreover, it allow us making the claim that as PSTs identify dilation, they attend to the relationship between the circles, rather than the relationship between a point and its corresponding image-point.

Excerpt 2: Acceptance and rejection of conjectures mediated by speech, image, dynamic visualization and gesture

Table 2: Transcript of examining the effect of Function 2.

Time	Speech	Action	Visual Mediator
[1:23]	PST 4: Let's see what happened.	PST 4 used the touchpad to move Point A in a circle-like path on the plane.	 Figure 2. A circle like path was created.
[01:43]	PST 4: It seems to be reflecting over a line. Do you see that?	PST 4 used the touchpad to move Point A in a circle-like path, then move the point from left to right around a line on the plane.	 Figure 3. Screen record of exploration of Function 2
[01:46]	PST 1: Yeah		
[01:48]	PST 4: But I don't know what line it is. It is not x=y.		
[01:49]	PST 1: It is not x=y.		
[01:52]	PST 2: So, wait …	PST 2 moved his pen to computer screen and aligned the pen to the emergent line on the screen.	 Figure 4. Hand and pen as the emergent line
[01:56]	PST 1: Doesn't that mean there is a point along that line is the same x?		
[02:00]	PST 2: So it is like...		
[02:03]	PST 1: not reflective over the line.		
…			

Following the given directions, PST 4 detached Point A from the constructed circle so that the pre-image could be any points on the plane. Then, she started moving Point A in a circle-like path on the plane, the trace of the image point of Point A appeared to be circle-like (Figure 2). Group members were observing the movement of the point, but nobody offered an observation or a conjecture. PST4 started moving Point A in a line-like path on the plane randomly. A "reflection line" was emerging as shown in Figure 3. PST # observed that the preimage points seems to be reflected over a line; this observation was was endorsed by PST 1. Then, PST 4 moved the points regularly around line x=y, which produced a cluster of points around the line x=y such as in figure 3. PST 4 pointed out that the reflection line is not x=y. PST 2 doubted at her conjecture, then he highlighted the reflection line emerging from the generated points by aligning his pen to the emergent line on the screen as shown in figure 4. As PST 1 keep moving Point A, more and more image points were generated, which do not fit the line x=y. PST 2's conjecture was rejected by PST 1.

In sum, we have shown that the acceptance or rejection of group observation and conjecture was not only mediated by the speech of group members but speech along with the consecutive static images from the dynamic visualization and group member gestures. Again, the analysis taking consider of multiple modes (i.e. speech, static images, dynamic visualization, gesture) allow us to conclude that PSTs did not see reflection as function on the plane, but realized it as reflection-symmetry effect that can be used to describe Function 2. Moreover, when exploring the effect of Function 2, PSTs moved Points A in three manners: circle-like path, line path, and swinging around line x=y. These actions indicated that PSTs had the intention to move point A in a systematical way, however, no perfect straight line movement were observed, such as movement along the x-axis, or line y=x, which revealed the constraint of the dynamic geometry environment: drawing perfect straight line, but not constructing straight lines, is not well accomplished by moving figures on computer touch pad.

Concluding Remarks

This paper presents an episode to demonstrate how PSTs collaboratively problem solving involves multiple modes of communication. In line with other researchers (Evans, Feenstra, Ryon, & McNeill, 2011; Perit Çakır, Zemel, & Stahl, 2009), we consider that mathematical knowledge building as the coordinated production and use of visual, narrative, and symbolic inscriptions as multiple realizations of co-constructed mathematical objects (Sfard, 2008). A contribution of the current study is to draw researchers' attention to the multimodal nature of group cognition and to find evidence of group collaboration, group thinking, and limitation of learning environment through multimodal analysis. Conceptualizing group cognition as multimodal discourse lead us to the conclusions on the two expects, which cannot be reached by attend to the verbal mode only.

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Collaborative Learning Across Space and Time: Ethnographic Research in Online Affinity Spaces

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Abstract: In this paper, we further articulate *connective ethnography* and consider how it may add to qualitative studies of collaborative learning in naturalistic, computer-mediated settings. Despite their physical separation, members of online affinity spaces work and learn together—they construct and review artifacts and share their work across sites. To trace these processes, we examine the complex artifacts and texts that constitute social practice in these spaces. We consider how expanding connective ethnography may meet researchers' needs in online contexts and we raise questions about how participants learn in these settings. Finally, we outline principles for an *affinity space ethnography* designed to capture the collaborative web of social interactions and audiences inherent to participation in affinity spaces.

Introduction: From New Spaces to New Methods

As young adults move many of their social interactions into online communities, researchers have called for further study of the literacies inherent in these spaces (e.g. Alvermann, 2008). The Pew Internet and American Life Project reports that youth participation in such communities is widespread: 73% use online social networks, 38% share original creative work online, and 21% remix their own or others' content (Lenhart, Purcell, Smith, & Zickhur, 2010). However, Grimes and Fields (2012) point out that these statistics typically consider only a small part of young people's internet activity: generally, their use of large networks like Facebook. In online spaces built for and by them, youth reframe and re-imagine content by creating original and transformative works such as fan fiction, artwork, and machinima. To do so, they work collaboratively, although distance often precludes face-to-face contact (Black, 2008; Lam, 2000). Members negotiate discourse norms (Lammers, 2013), form writing partnerships (Magnifico, 2012), disseminate practices (Fields & Kafai, 2009), and review each others' creations (Black, 2008).

Some scholars have conceptualized these communities as *affinity spaces*, or sites of informal learning where "newbies and masters and everyone else" interact around shared passions (Gee, 2004, p. 85). Online affinity spaces are loosely-organized arrays of separate, affiliated "portals" (Gee, 2004) connected by topic, links, and hashtags. Portals include root content sites (e.g. Neopets.com, the *Sims* wiki), creative archives (e.g. Fanfiction.net, DeviantArt.com), and social networks (e.g. Facebook, Tumblr). Though the field continues to theorize affinity spaces (e.g. Hayes & Duncan, 2012), typical research methods do not adequately account for these online interconnected networks of participants—or the learning that members accomplish together. We offer this paper as a beginning step in recommending new methods to gain insight into this kind of computer-supported collaborative learning.

Tools for structured observation are key methods for studying learning and literacies, particularly in these evolving settings. At the same time, online field sites are not traditional ethnographic field sites, and their activity cannot be captured in the same ways because places, researchers, observations, and participants become complex in online contexts (Leander & McKim, 2003), particularly when there are multiple paths to participation. As such, we first examine *connective ethnography's* open, descriptive stance towards capturing "traveling practices" (Leander & McKim, 2003, p. 212) among blended online and offline spaces. Then, we consider what it means to extend this framework as *affinity space ethnography* (Lammers, Curwood, & Magnifico, 2012), and how this step is necessary to study literacy practices across portals. While this step is modest, we believe it will enable clearer views of learning in the collaborative webs of social interactions, digital tools, artifacts, and discourses that are integral to affinity spaces.

Theory: Toward an Ethnography of Affinity Spaces

Connective Ethnography

Connective ethnography begins from an open, descriptive stance towards evolving spaces, as well as a desire to document resonance among online and offline contexts. This method is rooted in actor-network theory approaches to theorizing activity (Latour, 2005) and shows how practices travel across and among spaces and activities. The separation between online and physical spaces is deliberately blurred, unlike early research on digital learning and practice that suggested significant differences between these contexts (e.g. Markham, 1998).

Connective ethnography has been used primarily to create detailed tracings of people and their traveling practices, often using small numbers of participants (Lam, 2000; Leander & Lovvorn, 2006). A handful of larger studies of face-to-face and online communication in disciplinary communities (Hine, 2007) and practice initiation in tween gaming groups (Fields & Kafai, 2009) exist as well. Because affinity spaces have become multi-sited contexts where members collaborate *across* portals, we argue that describing the travel of members' practices and artifacts must become central. Fields and Kafai (2009) show how such documentation of tweens' virtual world usage can be accomplished by analyzing face-to-face video and back-end logfiles. In the following sections, we ask: how can we "connectively" trace participants' computer-supported collaborations through affinity spaces when these data streams are unavailable?

Tracing Texts and Artifacts

A typical assumption of ethnography is the face-to-face nature of activity and data collection. In online affinity spaces, though, communication is mediated through an array of digital tools. As connective ethnographers have articulated, researchers must understand how practices travel between online and face-to-face elements of blended practices to understand computer-supported learning (Leander & McKim, 2003). Here, we extend this thinking: Researchers must also understand how these activities travel across and through the multiple affiliated portals that support these actions. To do so, we must study how members work and learn together, often over substantial physical distance (Lam, 2000; Black, 2008), using text, computer code, and image creation. Tool-mediated communication is hardly exclusive to online sites (Latour, 2005; Prior, 2008), but texts and artifacts circulate in different ways from face-to-face customs and rituals. Unlike connective ethnographers of blended spaces, we may not have access to our participants' offline lives beyond self-reported experiences. Consequently, we cannot fully understand how their practices travel. While some may consider this a limitation, this condition mirrors participants' interactions and the ways in which they navigate online affinity spaces. Instead of speaking face-to-face, members communicate with complex mixed genres and artifacts (e.g. instant messages, tweets, Tumblr posts, artwork, videos) (Curwood, 2013). Such texts are necessarily compositional and communicative—multimodal practices of reading, response, and creation (cf. Prior, 2008)—and this complicates their analysis. Connective ethnographers may broadly map these digital traces, which travel between spaces as they are posted and linked (Hine, 2007). While this method is a useful step, online researchers must also (a) reconstruct artifacts' travel and evolution across portals, and (b) use such findings to further theorize the collaborative nature of online texts and how they support learning and participation.

Affinity Space Ethnography

With *affinity space ethnography*, we trace and map the connections among and across members' actions in diverse portals as they are represented in texts, artifacts, genres, and discourses. The findings generated by this method will be limited by partial access to participants (in similar ways as their own participation is limited by partial access to each other). We believe, however, that this work better represents adolescents' online lives and the new literacies that they nurture through their participation as fans, creators, and collaborators in affinity spaces. While Steinkuehler (2007) and others have documented "constellations" (p. 184) of multimodal literacy practices in online activities, and recent research has expanded conceptions of online participatory cultures (e.g. Ito, et al, 2010) and affinity spaces (e.g. Lammers, Curwood, & Magnifico, 2012; Hayes & Duncan, 2012), little research exists on how learning circulates among and across these online communities. Discussions of popular books and movies, for instance, may encompass diverse genres including fan fiction, role-playing games, and Twitter hashtags (Curwood, 2013). Despite physical separation, members collaboratively construct and review texts and artifacts, write guides for participation, and share their work across portals. They set boundaries for community Discourses (Gee, 1996), thereby creating norms and rules for productive participation (Lammers, 2013). Using multiple portals, genres and practices travel among sites and communities as members learn, create, collaborate, and respond to each other in diverse online venues.

Method: Enacting Affinity Space Ethnography

We argue that a new approach for studying computer-supported collaborative learning in multi-sited, technology-mediated settings is necessary. In previous work (Lammers, et al., 2012), we sought to update Gee's (2004) discussion of affinity spaces, considering how affinity spaces have evolved into groups of loosely affiliated, content-focused sites. Here, we build on connective ethnography to offer recommendations for enacting affinity space ethnography and illustrate them with the worked example of Curwood's (2013) *Hunger Games* affinity space study.

Sustained, systematic observation in an affinity space is a crucial first step for researchers to make sense of the culture and practices of a space. Such observation should focus on understanding the organization of the space, including traveling among and between the various portals to map connections and note how participants make use of each. Observations using such tools as forum archives can also help affinity space ethnographers learn about a portal's past activities in order to develop sociohistoric understandings. Sustained observation should also aim to determine the various roles available to participants, to trace how activity is distributed amongst participants, and to answer questions about what constitutes participation and activity for different users. To this end, Curwood has spent two years systematically observing participation in numerous *Hunger Games* affinity space portals.

Equipped with a deeper understanding of the organization and culture of an online, multi-sited field, attention can turn toward *analyzing artifacts*. To acquire a sense of a space's development, it's important to track the historical information represented by artifacts over time and across different portals. This analysis can offer the affinity space ethnographer insight into how participants' foci and interests have changed over time, as well as how they vary within different portals. The worked example below offers insight into how Curwood traced and analyzed such artifacts.

Finally, the affinity space ethnographer engages in *repeated contact with participants* to fill in the gaps and learn about their own interpretations. Such contact seeks to strengthen the researcher's understandings of the culture and practices within the affinity space, and thus must include contact with informants who enact a variety of roles identified during observation. To gain such insight into the *Hunger Games* affinity space, Curwood has maintained contact with over 30 adolescent participants who reside in the United States, United Kingdom, Canada, and Australia.

Worked Example: *The Hunger Games* and Affinity Space Ethnography

Recent years have seen a marked increase in the number of novels published for young adults, as well as increasing fan conversation, collaboration, and creation in online affinity spaces devoted to these works. For instance, Suzanne Collins's trilogy, *The Hunger Games*, has inspired expansive fan activity. Curwood's (2013) ethnographic study focuses on literacy practices in various *Hunger Games* portals where participants write fan fiction, create art, produce videos, compose music, and design role-playing games. These portals can be classified into three types: (1) root websites specific to *The Hunger Games* affinity space; (2) fandom websites that include transformative works from multiple affinity spaces, such as FanFiction.net and DeviantArt.com; and (3) social media tools that promote interaction within and beyond the affinity space, including Twitter and YouTube. Each portal serves as a potential entry point into the affinity space, and participants move across and through portals as they participate in the fandom.

In order to understand the culture of *The Hunger Games* affinity space, it is essential to examine how conversations, texts, and artifacts travel within multiple portals by engaging in sustained, systemic observation. Through such observations, Curwood met Olivia, one participant whom she has observed across all three types of portals for 16 months and interviewed four times. We describe Olivia's case to discuss how casual fan participation leads to deep situated learning over time. At 10 years old, Olivia began to write fanfiction in the fandom surrounding Collins's *Underland Chronicles*. Within a week of reading *The Hunger Games*, Olivia decided that she wanted to start her own portal, "a text-based role playing game [RPG] devoted to the world of Panem." Since 2008, Olivia's RPG portal has grown to include her own root website, links to Facebook and Twitter, and game recap videos on YouTube. Now 17, she discusses her learning: "My site in particular has changed me as a person and a reader both by helping me develop my writing skills and allowing me to befriend people from all over… that share a common interest."

An analysis of Olivia's artifacts over time supports her sense of her own learning. She has participated as a designer, moderator, and player since the RPG's inception, and her learning is particularly evident in her creative writing. A textual analysis of Olivia's 12 FanFiction.net stories and 2,600 forum posts suggests that her understanding of character development and her use of descriptive language have been positively shaped through the text-based RPG. For example, in 2008, Olivia's first *Hunger Games* fan fiction story was written from the perspective of a minor *Hunger Games* character, drawing heavily on events and dialogue that appeared in the original novels. An RPG from 2013 shows that Olivia's style has changed, however. In this game, she developed an entirely new character, using figurative language, poetry verses, and anecdotes to offer a richly detailed profile of a young girl. Content analysis reveals that, over time, Olivia's writing has grown increasingly complex, creative, and improvisational. While she began by relying on existing narratives to tell her stories, she now innovates within Collins's world of Panem.

In more traditional connective ethnographies, researchers often navigate online spaces and physical locations, engage in observations and other face-to-face data collection, and examine artifacts in order to study how practices and cultures travel across settings. Conducting research exclusively in online spaces challenges such methodological approaches. To gain insight into the culture of an affinity space, a researcher may need to participate in dozens of portals, access multiple social media tools, and examine multimodal artifacts. Alternatively, the researcher could follow a participant like Olivia in order to understand how her learning and texts travel across multiple portals. In order to uncover how affinity spaces function as collaborative learning environments, Curwood is tracing how Olivia's writing develops through role playing and interacting with other fans across time and space. Affinity space ethnography needs to trace texts and artifacts across multi-sited, ever-changing portals, without face-to-face access.

Conclusion: Moving Ethnography Forward

As educational and social venues move to online settings, researchers must develop new methods of understanding learning and interaction in these spaces. As the CSCL theme states, we must observe the activity of online worlds writ large *and* examine individual participants' artifacts to gain insight into the facets and travel of "grains of sand." Even where traditional and blended ethnographic observation is impossible, and complete accounts of participation unlikely, we can map portals, trace genres and practices, and glean information about participants' roles and activities. These are the methods and tools by which we attempt to reconstruct participants' situated and sociohistoric learning. Despite physical separation, members are apprenticed into online Discourses, and they learn how to take meaningful action in particular portals (Gee, 2004). At 10, Olivia joined a literature-based fandom; at 17, she's an avid reader, writer, and game designer. To trace and document this learning process, affinity space ethnographers must consider connections among texts and artifacts in spaces with compositional and communicative histories. As participants move through affinity space portals, so must researchers follow these traveling practices to understand how actions that may initially seem disconnected cohere into learning. We offer this discussion of affinity space ethnography as a modest step and needed expansion of connective ethnography, and as the beginning of a continuing conversation about online research sites and how researchers can gain explanatory footholds in complex, evolving spaces.

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Designing Soil Quality Mobile Inquiry For Middle School

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Abstract: LET'S GO aims to develop, implement, research, and scale a new paradigm to foster collaborative student learning in ecological sciences. We integrate geo-positional data sensing, participation frameworks for learner collaboration, mobile inquiry, reflection and information visualization tools to create science learning collaboratories. We describe motivations for our project and related research, discuss our experiences designing a pilot set of Soil Quality Inquiry activities, and the challenges faced.

Introduction

Learning science concepts and inquiry strategies should appropriate new tools from science—sensors for data capture, data visualization, low-cost mobiles for field-based science, and geo-tagged digital photos and videos for documenting field research. Inspired by Design-based Research (Cobb, diSessa, Lehrer, & Schauble, 2003), we have designed classroom interventions aimed at developing theoretical frameworks for domain-specific learning processes. Our first objective is to provide interactive educational activities and tools enabling students to participate in collaborative scientific inquiry as they craft hypotheses, and collect, analyze, compare and discuss local data while studying environmental and ecological sciences.

LET'S GO (Learning Ecology with Technologies from Science for Global Outcomes) convenes partners across disciplinary and geographical boundaries, and academic and commercial interests, sharing a vision of collaboratories (Bos et al. 2007) for mobile science. Guided by these aims, we design activities which integrate geo-positional data sensing, multimedia communication, data visualization and Web 2.0 tools in specific ecology learning scenarios, using co-design methods with teachers, learners, developers, learning and domain scientists on topics such as water quality, soil quality, ecosystems and biodiversity.

Inquiry Learning and Mobile Sensing

Inquiry learning is "an approach to learning that involves a process of exploring the natural or material world, and that leads to asking questions, making discoveries, and rigorously testing those discoveries in the search for new understanding" (National Science Foundation, 2000), In educational settings, inquiry learning in science is commonly embodied in project-enhanced science learning, where students engage in authentic, open-ended and motivating tasks extending over days and mediated by various tools and expertise. These tasks require collaboration and communication within—and sometimes beyond – the classroom, taking advantage of online data resources (Blumenfeld et al., 1991; Pea 1993, Quintana et al. 2004; Scanlon, Jones and Waycott, 2005; Tinker & Kracjik, 2002). These conditions are intended to support the social model of teaching and learning known as "cognitive apprenticeship" (Collins, Brown & Newman 1989) where authentic problem definition and problem-solving processes are guided by mentors, with learners gradually taking on increasingly complex tasks and autonomy as support fades.

More recently, rapid developments in mobile, wireless, and sensor technologies have provided new design possibilities for augmented learning activities that may be orchestrated across diverse environments such as schools, nature and science centers/museums (Rogers & Price, 2006; Roschelle & Pea, 2002; Scanlon et al. 2005; Sharples, Taylor and Vavoula, 2007). Building on this prior work, we are leveraging new mobile multimedia technologies, sensors, digital maps and interactive data visualization tools. Opportunities with open platforms and less costly component technologies make integral use of mobile science learning more broadly adoptable (Giemza, Bollen & Hoppe 2010, Vogel et al. 2010).

Co-designing for Mobile Science Inquiry Learning

The activities and tools we are designing explicitly support inquiry, integrating sensor data collection from school sites with a collaborative learning system using locally networked mobile devices. Our approach to designing the mobile science collaboratory is guided by use of Design-based Research (Cobb, diSessa, Lehrer, & Schauble, 2003) and co-design methodologies (Penuel, Roschelle & Schechtman 2007). Our design process involved co-design workshops teaming teachers, experts, science educators, learning researchers, software developers and learners. We conducted co-design workshops in Sweden and the US (Spikol et al., 2009; Maldonado & Pea, 2010), and piloted activities in both countries to yield feedback for revisions toward a more flexible curriculum adaptable to the local culture and educational system.

Inquiry activities and assessments were created that matched the standards for a 7th grade level science class using field inquiry practices and mobile technologies. The school offered additional constraints and possibilities: activities had to fit within the school periods, within the academic curriculum and each teacher's yearly lesson plan. Equipment, procedures, materials and assessments had to be standardized so as to be able to be deployed and evaluated several times throughout the day.

Our co-design team chose five devices for the present trials, based on their usefulness to the students' outdoor inquiry activities, and the feasibility of incorporating them quickly into the educational flow.

(1) A *smartphone* with built-in sensors (camera, GPS), and a mobile client application developed by the Linnaeus University Celekt team for students' data collection and related observations, using 3G networking for communication purposes (Vogel et al, 2010).

(2) *PASCO scientific's SPARK Science Learning System* with built-in sensor interface and additional sensors. Its handheld touchscreen science appliance enables data collection and visualization, and connects to different sensors to measure phenomena such as pH, temperature, humidity, and dissolved oxygen.

(3) *Livescribe*'s Pulse pen digitizes the users' notes, recording audio in sync with pen strokes. Student groups use this digital pen for data collection and recording discussions during field investigations. These conversations are later replayed by the team when reflecting on inquiry processes and report writing. Researchers can also study how students incorporate their classroom knowledge into the inquiry process.

(4) A *laptop computer* to visualize geolocated data by the groups for comparison and discussion across groups, and to prepare each group's presentation.

(5) A *digital video camera* for the teams to document their discussions and observations.

Mobile Inquiry Learning Activities in Schools

Following the success of our Water Quality Modules (Pea, Milrad, Maldonado, Vogel, Kurti, Spikol, 2012; Maldonado & Pea, 2010), the LET'S GO co-design team chose Soil Quality as the next focal science topic to address the critical unmet need for Soil Quality lesson plans and activities in classrooms, particularly at the middle- and high-school level (Collins, 2008). Understanding basic aspects of Soil Quality is necessary for making decisions on sustainable land uses, at a personal and civic level. Today's students will soon be voting on issues like soil depletion, food security, soil erosion, sustainability, biofuel, and climate change.

Our team narrowed the activities' goals to four key concepts about Soil Quality: (1) importance of Soil Quality to plant and human life; (2) Soil Quality is a scale, not a binary judgment, composed of many micro- and macro-properties of soil; (3) existence of macro- and micro-organisms in soil such as groundworms (nematodes), which reflect and contribute to Soil Quality; and (4) the interaction of these macro- and micro-characteristics of the soil have a clear effect on the (plant) life supported by soil, impacting its ability to grow and propagate, as well as other features such as color.

We developed formal student roles in terms of group-worthy activities (Lotan, 2003): 'documentary filmmaker,' 'lab technician,' 'reporter,' 'data scientist.' Each role contributes a different, significant part of the inquiry activity. Groups decided on their own rotation pattern for the roles, so that each student in a group would have the opportunity to fulfill each of the roles and responsibilities on different days. By empowering the students to record their own video, we hoped to gain an insight into their attention process, as it quickly became apparent that the students' video focus differed from that of researchers.

The LET'S GO Soil Quality Inquiry Modules

Our final design called for four activities, implemented across three to four classes lasting 90 to 120-minutes. The first two inquiry activities were conducted inside class, with the third and fourth outdoors on school grounds. Students' inquiry processes would be scaffolded heavily during the first module, and gradually these scaffolds would fade throughout the sessions (Collins et al.,1989). Activities were designed to appeal to the intended audience in presentation and level of pre-existing knowledge, and to introduce gradually the concepts and inquiry processes.

Figure 1: (A) *'Is Soil Alive?'* Students evaluating the composition of a soil sample in the classroom. (B) '*PlantSmart Mystery*': Students measuring Soil Respiration. (C) Hydrangea plants' color-pH correlation.

Figure 2: 24-hours of PlantSmart sensor readings: (A) Soil Moisture, (B) Sunlight Data, (C) Temperature.

The four LET'S GO Soil Quality activities are:

(1) *Is Soil Alive?* Students learn to use sensors to measure soil respiration rates of different types of soil. They then contrast these results with data obtained through guided observation and evaluation of soil samples (see Figure 1A) to answer questions such as: What does the soil sample smell like? What color is it? What is its texture? What is it made of? The goal is to have students link properties of the soil that they can observe, such as the prevalence of organic matter, with the invisible characteristics of Soil Quality – in this case, soil respiration, and, through this link, to discover the invisible layer of the soil ecosystem.

(2) *Understanding the Effects of pH*. the second activity, examines the link between invisible properties of the soil and the impact on the life sustained by that soil. It addresses two key student misconceptions: first, how despite the fact that soil pH cannot be directly observed, it has visible effects on the life that grows upon that soil. Secondly, students are keen to assign the labels of 'good' and 'bad' to pH values that deviate from the center of the scale. Yet even pH levels that may not be ideal for sustaining *human* life can sustain beautiful life forms.

We focused our activity around soil samples from differently colored Hydrangea plants (known as Hortensia). These small flowering bushes are common and inexpensive, and more importantly, several of the varieties (most notably Hydrangea Macrophylla and Hydrangea Serrata) have the property that the color of their flowers is affected by the soil pH . An acidic soil ($pH < 6$) will usually produce flowers with blue coloration, whereas a more alkaline soil ($pH > 6$) will produce pink flowers (see Figure 1C). Students were presented with a wide-range of hydrangea plants from which to choose several soil samples to evaluate their pH. This exercise offers an immediate view into how a single invisible property of soil directly impacts the life supported by the soil.

(3) *PlantSmart Mystery.* PlantSmart sensors are inexpensive and measure sunlight exposure, temperature and soil moisture over time. In this activity, we placed eight of these sensors for 24 hours in different locations around the school campus. The data was then downloaded to the computer, and each student group received the information for all eight sensors, labeled with letters (Sensor A, Sensor B, etc). A typical example of these readings is visible in Figure 2. The students also received a list of GPS coordinates for all eight sensors labeled numerically (Sensor 1, Sensor 2, etc). From the latter list, each group was 'assigned' a sensor. The groups' task was to design an inquiry that would allow them to decide which of the sensor readings matched their assigned sensor site. To design their inquiry experiment, the students could choose which measures to collect from their assigned location, including collecting measurements with the PASCO sensors with which they had prior experience (see Figure 1B) for an example of a group working on their '*PlantSmart Mystery*' activity).

One of the intentional challenges student groups faced in this activity was that the PlantSmart sensor readings are given qualitatively (see Figure 2): for example, temperature is reported on a six-point scale: Cold, Cool, Moderate, Warm, Hot, Very Hot. Within their group, students had to make their own judgments to transition between the data collected by the PlantSmart sensors qualitatively and the quantitative data they collected through the PASCO sensors.

(4) *'Can My Site Support Life?'*, the fourth activity was originally linked with the prior activity during our pilot deployment, although we have since separated them. The students groups are asked to answer how their site may support life through an inquiry they design among themselves. We kept the same GPS coordinate site as for the prior activity, but the focus shifts from gathering data about soil characteristics in the '*PlantSmart Mystery'* activity. For this last Soil Quality activity, we want students to move upwards in the level of abstraction, and make conclusions about Soil Quality of their site based on the soil characteristics. At the end, each group prepared a presentation for the class, following a template that scaffolded their inquiry.

Next Steps

The four Soil Quality modules we have outlined were experienced by twenty-four students at a local middle school. We are currently evaluating the results from this intervention through video analysis, as well as qualitative and quantitative assessments.

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Blended Learning Experiences in a Multimodal Setting: The Impact of Communication Channels and Learners' CMC Expertise on Perceived Social Presence and Motivation

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Abstract: Virtual learning environments are increasingly used to support online and blended learning settings. Yet, little is known about how different synchronous communication modalities influence students' perceptions of social presence in learning settings. Existing laboratory research indicates that social presence is negatively affected when communication cues are reduced to text. Using a within-subject design, we investigated whether differences in communication modality (1. chat, 2. audio, and 3. audio-video) affect social presence and motivation in a blended learning seminar. Results show in contrast to laboratory findings that communication modality did not directly affect students' perceptions of social presence. Instead, expertise in computer-mediated communication (CMC) appeared as important moderating variable that facilitated the perception of social presence as well as motivation in the chat modality more strongly than in audio or audio-video. Current results provide new insights and practical implications for online learning settings that use synchronous CMC.

Introduction

Virtual learning environments (VLE) as communication platforms constitute the surrounding for social interactions and perceptions through which collaborative online learning takes place. In VLE "the technological mediation of interaction and communication creates an additional layer of mediation with and through which learners must interact" (Hillman et al., 1994 cited in Johnson, Gueutal, & Falbe, 2009, p. 547). This layer affects the mode of communication, perception of physically separated individuals as well as the learning experience as a whole. Social presence, defined by Short, William and Christie (1976) as the "degree of salience of the other person in the interaction and the consequent salience of the interpersonal relationships" (p. 65), was recognized as a fundamental factor to enhance social interaction, which is the major vehicle of social learning in VLE (Tu, 2000). It was found to be positively related to the socio-emotional climate, especially to social dynamic and motivation (Gunawardena & McIsaac, 2004). Nonetheless only a few studies in the context of learning investigate social presence in synchronous CMC, especially in terms of comparing different communication modalities. By varying synchronous conversation modes (chat, audio, audio-video) in avatar related laboratory studies (Bente, Rüggenberg, Krämer, & Eschenburg, 2008; Sallnäs, 2002) less social presence was perceived in conversations via chat in comparison to CMC via audio or audio-video. The goal of the current study was to test if prior laboratory findings for synchronous CMC modalities (chat, audio, audio-video) can be replicated in a field experiment within a VLE used for a blended learning seminar. We explored whether communication modalities affect the perception of social presence and took particularly the factor of expertise with regard to CMC into account, as it was found to facilitate the reception of social presence in text-based CMC (Mykota & Duncan, 2007; Wrench & Punyanunt-Carter, 2007). Furthermore, we analyzed the impact of communication modalities on students' motivation to gain new insights for the improvement of CMC learning settings.

Theoretical Background

Short et al. (1976) stated in their original work that the capabilities of media to transfer nonverbal social cues determine the degree of social presence. From this line of argumentation, one can infer that communication modalities that convey more cues lead to a higher degree of perceived social presence. This perspective is in line with the reduced social cues approach (Kiesler, Siegel & McGuire, 1984) and takes into account that channel restrictions (e.g. text only) affect the degree of delivered social cues (e.g. via facial expressions, gestures, intonation of voice) and consequently the amount of perceivable social presence. Researchers questioned the idea that properties of media are the most salient determining factor for establishing social presence (Garrison, Anderson, & Archer, 2000; Gunawardena, 1995; Walther, 1992). Others have argued that the perception of social presence is interindividually different and varies greatly, even for the same communication medium (Johansen, Vallee, & Spangler, 1988; Lombard & Ditton, 1997). In line with evidence for both perspectives (see e.g. Lee & Nass, 2005 for a review), Tu (2002) points out: "Social presence is a dynamic variable based upon the user's perception and the characteristics of the medium." (p. 3) The current study therefore investigated synchronous CMC modalities as independent variable, and learners' expertise with regard to CMC as moderating factor in relation to social presence.

Social Presence and Learners' CMC Expertise

As proposed by Short et al. (1976) it can be expected that the less social cues are conveyed via synchronous communication modalities, the less social presence is perceived. Subsequent studies (Bente et al., 2008; Sallnäs, 2002) affirmed that social presence is perceived to a lower degree in synchronous communication via chat in comparison to audio or audio-video, but also showed that audio did not differ from audio-video with regard to social presence. Therefore we propose:

H1: The amount of perceived social presence is lower in text-based CMC in comparison to audio or audio-video CMC.

Following Walthers' (1992) social information processing perspective, individuals are able to compensate missing cues in CMC situations – e.g in text-based communication by using and interpreting creative constructions like acronyms or emoticons to communicate nonverbal information (Walther & Tidwell, 1995) – and can perceive text based CMC situations even as rich as face-to-face communication. The degree to which users are able to intensify CMC socio-emotionally thereby depends on the acquired experiences and competences over time with certain communication media (Walther, 1996). Research has shown that CMC skills have a positive impact on the perception of social presence in text-based communication (Mykota & Duncan, 2007; Wrench & Punyanunt-Carter, 2007). This indicates that familiarity with CMC modes affects social information processing and thereby the level of social presence that is perceived in a VLE. As more naturally produced social cues that can be interpreted automatically are transmitted in CMC via audio (e.g. sound, intonation of voice) or added video (e.g. facial expressions, gestures) in comparison to text-based communication, an interaction effect of learners' CMC expertise and communication modality is expected:

H2: CMC expertise has a more positive impact on the perception of social presence in text-based CMC than in audio or audio-video based CMC.

Moreover, the current study exploratorily assessed if communication modalities influence students' motivation towards learning via VLE as a major factor with regard to learning. As social presence was found to be positively related to motivation (Gunawardena & McIsaac, 2004) and research is needed to determine the extent (Richardson & Swan, 2003), this issue was additionally addressed.

Method

Altogether, 17 students from two German universities took part in a blended learning seminar using Adobe Connect as VLE. The seminar consisted of 3 face-to-face meetings as well as 9 online sessions, while the latter were divided in 3 units, each containing three 90 minutes long interactive online sessions that were hold in the VLE. With the units, predefined synchronous communication modalities (1. chat, 2. audio, 3. audio-video) were varied over time (within-subject) with a stepwise conjunction of modalities.

Before the first unit (chat), a pre-questionnaire was administered to measure learners' CMC expertise. The scale consisted of 4 items that measured the frequency of using online communication tools (e.g. Blogs) from *never* (1) to *very often* (5). After each unit, social presence and motivation tailored towards the perception of online sessions within the unit were measured as dependent variables on 5-point Likert scales ranging from *completely disagree* (1) to *completely agree* (5). Social presence was measured with the two subscales *co-presence* (8 items) and *perceived attentional engagement* (6 items) adapted from Biocca and Harms (2003) that were selected because of their perfect applicability in the seminar context. Co-presence is related to the degree to which one feels that others are together in the same space. Perceived attentional engagement measures the degree to which one pays attention/is distracted as a basal, primitive factor for feeling social presence. Motivation was assessed via 7 items adopted from the Intrinsic Motivation Questionnaire (Deci, & Ryan, 1985), measuring enjoyment and perceived value.

Results

Reliability tests for all scales revealed satisfactory to high internal consistencies (Cronbach's $\alpha > .72$). A repeated measures ANOVA was calculated to test effects of communication modalities on *social presence*. H1 was not supported as no significant main effect was found, that is, audio or audio-video did not outperform chat with regard to social presence (Table 1).

Table 1: Means (*M*) and Standard Deviations (*SD*) for social presence and motivation in different communication modalities.

	Social Presence		Motivation	
	M	*SD*	*M*	*SD*
Chat	3.45	.52	3.28	.79
Audio	3.58	.38	3.43	.58
Audio-Video	3.38	.52	3.02	.91

Regression techniques were applied to test effects of person characteristics on the influence of within-subject factors (Judd, Kenny, & McClelland, 2001) to analyze the effect of CMC expertise on the perception of social presence in relationship to different communication modalities. First, it was examined if CMC expertise moderated the perception of social presence in the chat modality stronger in comparison to audio and audio-video modalities with more social cues. To test H2, a weighted difference score for social presence (audio + audio-video – 2*chat) was regressed on CMC expertise, which emerged as a predictor on the 10% level of significance (β = -.598, t = -2.237, p = .052, R^2 = .283). In line with H2, CMC expertise related more strongly to the perception of social presence (learners with more CMC expertise felt more social presence) in the chat modality than in the audio or audio-video modalities. When comparing single conditions with each other, CMC expertise did not emerge as a significant predictor for the difference scores audio-video minus audio as well as audio minus chat, but for the difference score audio-video minus chat (β = -.603, t = -2.27, p = .050, R^2 = .292) with a similar interaction: CMC expertise moderated social presence in the chat modality more strongly than in the audio-video modality whereby learners with more CMC expertise perceived more social presence than learners with less CMC expertise.

A repeated measures ANOVA was calculated to test effects of communication modalities on students' *motivation*. No significant main effect occurred. Additionally the same regression techniques as above were applied to investigate a possible interaction effect between CMC expertise and communication modalities with regard to motivation. First, a weighted difference score for motivation (audio + video – 2*chat) was regressed over CMC expertise that predicted the difference score (β = -.604, t = -2.397, p = .038, R^2 = .301) with a similar pattern as with regard to social presence. CMC expertise moderated motivation more strongly in the chat modality (learners with more CMC expertise perceived more motivation) than in audio or audio-video. By comparing single conditions with each other, the same interaction occurred for motivation difference scores between video and chat (β = -.591, t = -2.32, p = .043, R^2 = .284) as well as audio and chat (β = -.568, t = -2.67, p = .017, R^2 = .277), whereas CMC expertise was no significant predictor for the motivation difference score between audio and audio-video. Thus, in contrast to social presence, CMC expertise moderated the treatment difference with regard to motivation between audio and chat.

Correlation analyses, investigating preferences for learning in specific modalities, showed in line with previous findings that learners who were motivated with audio as communication modality did also like audio-video (r = .90, p < .001), whereas the motivation values for chat did not correlate significantly with audio or audio-video. With regard to the relationship between social presence and motivation, analyses revealed significant correlations in the chat (r = .55, p = .026) and audio-video modality (r = .60, p = .048), whereas not in the audio modality.

Discussion

The goal of the present study was to test if prior laboratory findings for social presence can be replicated in a field experiment within a VLE, and to additionally investigate motivation as well as learners' CMC expertise as moderating factor. According to our findings, it is unclear how reduced communication cues affect the perception of social presence in VLE. Present results indicate that CMC expertise is an intervening factor that supports the perception of social presence and becomes more important if communication occurs via chat in comparison to audio/video, whereas communication modalities did not directly affect the perception of social presence. The latter fact stands in contrast to Short et al.'s (1976) expositions and previous results from laboratory studies (Bente et al., 2008; Sallnäs, 2002), what can be explained by the small sample size, differing operationalizations of social presence or a sequence effect regarding modalities that was caused by the study design; but might also be due to the fact that interactions via VLE took place for a longer period of time and under different circumstances (e.g. to acquire knowledge) compared to the prior results from the laboratory. It is important to note that results need to be treated with caution, because sequence effects could not be ruled out as there was no possibility to rotate CMC modalities in a university course setting due to practical didactic constraints. Therefore field and laboratory studies have to be conducted, that control additional factors (e.g. sequence, interaction time, involvement) which may interfere. However, current findings support in line with empirical results (Mykota & Duncan, 2007; Wrench & Punyanunt-Carter, 2007) and Walther (1996) that expertise with regard to CMC intervenes in the processing of social information delivered by CMC. In the current study, learners´ CMC expertise had a more positive influence on the perception of social presence if communication cues appeared on a text-chat basis in comparison to auditory or audio-visual cues. Even though the difference in social presence between chat and audio was not predicted by CMC expertise, CMC expertise seems to become more important if acronyms and emoticons replace naturally produced social cues. The less social cues are transmitted by communication modalities that can be interpreted instinctively, the more CMC expertise seems to be needed to perceive others as socially present. Further studies need to investigate which specific CMC skills and competences are required to perceive a high degree of social presence in a social cue reduced environment. With regard to motivation the current study gives insights, that it is interconnected to CMC expertise in a similar way as social presence. Interestingly, students who were motivated in auditory sessions were also motivated in audio-visual sessions, whereas no connections with regard to motivation in chat sessions were found. This indicates that preferences for communication modalities may differ depending on CMC expertise, with learners with less CMC expertise preferring communication modalities with many social cues. However, as CMC expertise did not just impact the degree to which social presence was perceived but also the motivation to participate in online sessions, learners' CMC expertise can be stated as an important prerequisite for successful interactive online seminars on a text basis. Consequently prior trainings for learners with low CMC expertise to learn to adapt to text-based CMC should be able to support rich text-based learning experiences that involve social presence as well as motivation.

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Educator roles that support students in online environments

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Abstract: Potential generative outcomes of participation in online learning communities are documented, alongside inequities in terms of who is participating. We share a blended multi-level approach to identify and explore educator roles played to support 11-to-13-year olds' learning, participation, and development in one online learning environment.

Introduction

As online learning environments rapidly become part of the education landscape, new methods to make sense of what is occurring in these environments are critical. Although web-based systems can automatically collect enormous amounts of user data, there is much we as a field need to understand about what to examine and how to analyze what we see to reveal patterns of learning. Positive outcomes of participation in such environments are documented, but so too are inequities in the ways different populations access and use such online opportunities. In this paper, we present a blended approach of community-level automated analytics and more individual qualitative interpretation to look at educator roles played to support student learning in one online learning environment designed for middle school.

Online learning environments, outcomes, and inequities

In 2010, over six million students participated in online learning at postsecondary institutions in the United States, a ten percent growth rate from the previous year (Allen & Seaman, 2011). Recently, massively open online courses taught through platforms such as Coursera and edX, offer free online classes to students around the world. The rise is apparent for K12 as well. In 2008, an estimated 75% of public schools had one or more students enrolled in a fully online or blended course, and 66% estimated that their online offerings would grow (Picciano & Seaman, 2009). Open source platforms offering teachers a customizable online classroom space are increasingly successful, including Moodle and EdModo.

Learning content knowledge is one potential outcome of participation in online learning environments, as students are introduced to new information and submit assignments. Many environments now incorporate a variety of interactive and social features allowing students to go beyond retrieval and submission of information, moving to collaborative production, processing, and understanding. We refer to these spaces as online social learning networks. Within these networked community contexts, less traditional results have been documented that are believed by some to be important pieces of the 21st century skillset, including managing information, directing learning pathways, collaborating, discussion and critique around common artifacts, and building collective intelligence (Barron, Gomez, Pinkard, & Martin, in press; Jenkins, Purushotma, Weigel, Clinton, & Robison, 2009).

But only a subset of people participates in ways that can lead to these positive outcomes (Hargittai & Walejko, 2008, Jenkins et al., 2009). A new digital divide has been identified not in terms of access to technology, but in terms of who has the opportunities, support, and knowledge to truly participate. A knowledgeable social network is one important piece of this system. Parents and other home connections can be highly instrumental in guiding learning and participation (Barron, Martin, Takeuchi, & Fithian, 2009) but for many families, parent technological knowledge and co-participation is not the norm (Warschauer & Matuchniak, 2010). There is evidence, however, that informal spaces such as afterschool spaces and community centers, can provide knowledgeable social networks for young people (Barron et al., in press). Online spaces have the potential to support and supplement these face-to-face opportunities.

Context: Digital Youth Network

The Digital Youth Network (DYN) is a mix of school, afterschool, and online spaces designed to provide youth with opportunities to develop traditional and digital literacy within a supportive and interactive community. Programming is offered through schools and libraries, specifically targeting urban populations.

Previous research within a school-based implementation of DYN highlighted the central position of DYN educators for student's technology-related learning, experiences, and development, more so than adults at home. Educators were aware of their critical position within DYN and revealed complexities and tensions that went hand-in-hand with this status, including difficulty finding a balance between being a teacher and evaluator alongside being a friend and mentor (Barron et al, in press).

iRemix is the DYN online social learning environment, which has become increasingly central as programming scaled up and face-to-face time has become more distributed. iRemix has an interface and functionality similar to popular online social network communities, and students are able to create a profile page, link to peers, and share and critique work. Users, including students and educators, share perspectives and create dialogue through blogs, forums, and mediated debates. In addition to using iRemix in classes, students are encouraged to use iRemix as an extension of classroom activities, and personally to develop as individual and collective participants over time. Given the central role of educators and the increasing reliance on interactions within the online iRemix space, we set out to document educator activity online to learn more about what was happening and reflect on potential for redesign.

Methods

Participants

The DYN instance presented here blended face-to-face school day classes and online participation for three sixth grade classrooms (N=79 students, 46% female) at a public charter K-8 school. The school was located an urban environment, with 725 students, 99% of whom were African American, and 86% of whom were receiving free or reduced lunch benefits (one measure of socio-economic status). The DYN classes focused on traditional and digital literacies and were taught by two teachers who specialized in reading and writing and two teachers who specialized in media arts. All of the educators and students involved in the classes were required to spend time on iRemix in addition to their face-to-face classroom time. Two additional adult mentors were responsible for online interactions only (i.e. they were not in the classroom). In all, there were six educators (50% female).

Coding framework and analysis

Our framework for educator roles online is based on work by Barron et al. (2009) that used case studies of eight highly technologically engaged middle school students from Silicon Valley to identify influential roles played by parents. These roles included: Teacher, Collaborator, Learning broker, Resource provider, Learner, Non-technical support, Employer, and Monitor. Together with DYN educators as our design partners, we examined and discussed these roles in the context of DYN. First, DYN educators shared verbal examples and reflections from their own online and face-to-face interactions with students. Next, archived digital histories of DYN educators were explored on iRemix, excerpting screenshot examples and discussing as a group. Through several cycles of collaborative review and discussion, and category refinement, a set of learning support roles that apply to adult educators within an online social learning network were defined. These included the existing roles of Learning broker, Monitor, and Resource provider, and the new roles of Audience, Encourager, Evaluator, Friend, Model, and Promoter. In addition, we slightly reconceptualized the role of Teacher and defined an Instructor role. The full set of roles is summarized in Table 1. The roles of Collaborator (play a role on a group project alongside youth) and Learner (learn from youth) were important face-to-face interactions discussed by mentors and will be incorporated into the coding scheme if evidence is found online.

iRemix was intentionally designed to collect and report use data, including logins and particular actions (including *read* (viewing work or posts), *create* (posting media or starting a blogpost), *comment* (adding a comment to posted work or discussion) and *rate* (formally assessing posted work)). Authors determined what pre-existing logged actions could be automatically coded as a role and what needed to be interpreted by hand. All instances of educators *reading* a student post were automatically coded for the role of Audience. Educator *comments* on student work and educator posts to the site were automatically logged but needed human interpretation of the content to determine the type of role evident.

For this study, we looked at the online educator activities on the iRemix space during a three-month class unit, from March 17 through June 20, 2012. There were 2221 actions logged as adult roles during this time; 1824 actions were automatically coded and 397 actions were determined to need human interpretation. Two co-authors coded a subset (25%) of the actions that needed human interpretation (educator comments and posts) and reached reliability of 86.4%. Coding discrepancies were discussed and agreements about coding were reached to mediate ambiguity in the coding scheme going forward. A FileMaker Pro collaborative database with a portal into iRemix was used to code the activity instances.

Table 1. Coding scheme for adult learning support roles online. (A) Indicates automatically coded actions. (H) Indicates actions that require interpretation and were coded by hand.

Role Definition	Examples from iRemix
Audience. View what youth are doing online	(A) View or read student work
Encourager. Encourage youth about work or participation	(H) Comment: *Jamie this is pimp, the details from the shoes to the chain are nice. Great Job!!*
Evaluator. Provide grades, ratings, badges, or other formal assessments	(A) Rate student work (A) Award or create badge
Friend. Exhibit personal approachability/ friendship/mentorship, including social posts, off-topic conversation	(A) Post a status update (A) Edit/create profile page (H) Comment: *LOL! I love Boondocks, too!*

Learning Broker. Connect youth with learning opportunities (people, activities, etc.)	(H) Comment: *check [how to do this] with Ms. Ammond or Mr. Vireo.*
Model. Share own creative work/process	(H) Blogpost: [Animation created by educator]
Monitor. Impose or suggest rules of behavior online	(H) Comment: *This is not appropriate and I don't expect to see content like this anymore. If I see it again you will lose your privileges permanently!*
Promoter. Showcase youth participant work	(A) Feature student work on front page of site (H) Blogpost: [Embed class-created e-zine]
Resource Provider. Provide learning resources (how-to guides, links, embedded media, etc.)	(H) Blogpost: *Use this link.* [link] (H) Posted document: *ExportingFromiMovie.doc*
Instructor. Directly teach a concept or skill or provide an assignment. Provide prompts and/or feedback to further student thinking or work	(A) Create a debate (H) Blogpost: *Create a story based on a character's trajectory of choices. It must be 3 paragraphs and include character names, settings and a creative plot.* (H) Comment: *I'd love to see a step by step on how you made this piece.*

Preliminary results

Educator logins ranged from 19 to 97, with an average of 58 logins during the three-month period. The number of logins was not an indicator of number of activities enacted with the space. Although we are still working on hand coding the full set of comments and posts, we provide initial findings to date.

Audience for student work

In today's classrooms, teachers need to deeply understand not only the content, but also the personalities, interests, and abilities of their students (Darling-Hammond, 2008). DYN educators used iRemix as a window into student work and what students they were doing outside of the classroom. An overwhelming majority of the actions logged by educators online reflects the Audience role (1812 instances across educators, representing 82% of the total role actions logged), including viewing student-created media assignments, profile pages, personal blogposts, and interactive discussions. What is not yet clear is the extent to which students were aware of their adult audience and if it motivated participation on the site.

There were only 12 instances of automatically coded roles that were not Audience. The Friend role occurred eight times, reflecting educators updating their profile page or posting a status updates. The Instructor role occurred two times, reflecting educators creating debate activities. The Evaluator role occurred twice, reflecting both creating a new type of badge and a formal rating of student work. These results indicate that although features exist in iRemix designed to promote and support student and teacher interactions around learning roles, such as a "Feature" button to push student work out to the home page, these aspects of the site were not frequently being used. Further research is needed to determine why. Educators may not have been aware of certain features or may have made deliberate decisions about interaction, such as believing evaluation of student work to be something best done face-to-face.

Connections with individual students

The online social learning network offered opportunities to support students individually, something that has been documented to be especially important in urban schools (Brown, 2004), but that is often difficult within the real-time complexities of the face-to-face classroom environment. Reading student work (Audience role), providing formal assessments (Evaluator role), and commenting on student work (multiple roles) represent roles played by an educator for an individual student as opposed to the entire group. Although there is evidence of educators enacting roles for a group of students, such as submitting status updates and posting an assignment or a resource for the class, the vast majority (97%) of the actions logged online were targeted toward an individual. Even when the Audience role is removed from the count to reflect those roles that are more interactive, roles played for individual students remain the most common pattern in the online space (87%). Although we have not finished coding the comments, the subset that we have coded span seven roles and the majority of comments reflect two roles in particular: 83% had a segment of the comment coded as Instructor and 55% had a segment coded as Encourager. A common interaction involves a student posting work and an educator responding with an encouraging statement followed by suggestions or prompts for additional work or thinking, as in the example below:

> Student post: *Theres nothing as great as a dear old sunset / setting in the west / its as beautiful as a rainbow / the sun is so close to the ground / yellow orange pink purple blue / it is so pretty / you know that night is coming / a sunset is a sign of night / sunset...*

Mentor comment: *I really like how you compared a sunset to a rainbow. You should add more descriptions. Describe how the day is different during sundown. Very nice job, so far.*

Gender patterns

Though we have a small sample, patterns were visible that need to be explored in more depth. Female educators evidenced more online actions counted as a learning support role. Males ranged from 66 to 276 role actions (M=168.70 SE=117.61) while females ranged from 164 to 783 (M=574.67, SE=117.61).

Implications and future work

This work is part of a larger initiative to understand interactions between members of an online social learning network over time and we believe findings will be generalizable beyond iRemix. This first study specifically looks at the different roles that adult educators play to support students in an online environment. After hand coding logged actions that need human interpretation and running analysis on the full dataset we intend to compare patterns of educator and student activities to explore impact of adult roles on student work and participation and look at variation between educators.

We see important implications for research, design, and practice. Understanding of the roles that are being played and not played and different generative outcomes that emerge from these direct actions can help us to design online supports for desired actions and outcomes. This work also offers a language and framework to share ideas and findings with practitioners during professional development sessions, aiding in discussing and understanding the complexities of taking on multiple roles intentionality around enacting certain behaviors at key moments to achieve certain instruction and/or interactive goals. Above all, it is an exploration of the online learning environment as a space that can provide youth with a knowledgeable social network to support their learning and development.

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Fostering Math Engagement with Mobiles

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Abstract: Everyday life is a rich context for mathematical thinking and learning across a wide range of activities, yet students' everyday mathematical competencies rarely see light in school. Mobile devices, such as smartphones and media players, can provide a much needed technical infrastructure for linking the mathematics of school with students' lives and experiences outside of school. In support of this claim, we present results from a study where students used mobile devices to engage in mathematical problem solving, with problems drawn in part from their out-of-school interests and experiences. Findings suggest that mobile devices, properly deployed, can help provide ease the process of making connections between the informal competencies that students bring with them to school, and the disciplinary competencies that schools most hope to foster.

Introduction

Everyday life is a rich context for mathematical thinking and learning across a wide range of activities, from dieting (de la Rocha, 1985), to sports (Nasir, 2000), to personal finance (Martin, Goldman, & Jiménez, 2009). Yet students' everyday mathematical competencies rarely see light in school. There are many calls in the literature for researchers and educators to bridge the gap between students' out-of-school experiences and the mathematics of school (e.g., Civil, 2002; Nasir, Hand, & Taylor, 2008). Yet there are a number of pervasive barriers to bringing together the mathematical thinking and learning that takes place across these distinct contexts. Among these barriers are:

- Differences between in-school math practices (e.g., abstract, precise, content driven, extrinsically evaluated) and out-of-school math practices (e.g., concrete, problem- and values-driven, intrinsically evaluated) (Esmonde et al., 2012)
- Student and teacher beliefs about "what counts as math" typically privilege in-school content and contexts (Abreu & Cline, 2003; Martin & Gourley-Delaney, 2011)
- Lack of teacher knowledge of mathematics in students' lives outside of school (González, Andrade, Civil, & Moll, 2001)
- Lack of student skill in mathematizing their out-of-school experiences (cf. Lesh, 2003)

Typically, the only means for connecting these distinct contexts, and for carrying ideas, artifacts, and representations across the in-school / out-of-school divide, is to rely on students and teachers. While this can be successful, in the absence of a dedicated team of researchers or other support staff, efforts will remain largely ad hoc and idiosyncratic. We argue that mobile devices, such as smartphones and media players, can provide a much needed technical infrastructure for linking the mathematics of school with students' lives and experiences outside of school. Mobiles have unique potential to erode the barriers identified above. In support of this claim, we present results from a two-week study where students used mobile devices to engage in mathematical problem solving, with problems drawn in part from their out-of-school interests and experiences.

Theoretical Framework

Mobile devices such as smartphones and media players are attractive educational technologies for a number of reasons: they are relatively low cost, have low barriers to use, are increasingly powerful, and are increasingly ubiquitous in the lives of young people. A number of innovative research and development studies have shown the power of mobiles for creating opportunities for deeper engagement with core disciplinary practices (Roschelle et al., 2010; White & Pea, 2011; White, Wallace, & Lai, 2012). Others have looked at the role of mobiles in informal mathematics learning outside of school (e.g., Jimenéz et al., 2010). We focus here on the potential of mobiles to bridge the divide between school math and students' knowledge and experience from outside of school.

In doing so, we leverage four characteristic informal digital practices associated with mobile devices. Specifically, mobiles enable 1) *capturing and collecting* photos, videos, and audio; 2) *communicating and collaborating* via text, email, phone, and video chat; 3) *viewing, consuming, and analyzing* text and media acquired from the internet or from peers; and 4) *representing and creating* new media and representations using a variety of apps (White, Booker, Ching, & Martin, 2012). We see in these four practices parallels with core mathematical practices of data collection, argumentation, and the creation, critique, and analysis of multiple representations.

Although our work is at an early stage of development, we draw inspiration from a thread of research that spans the learning sciences on how to build new, disciplinary knowledge from students' existing competencies, whether those competencies lie in everyday physics (Bryce & Macmillan, 2005), verbal language play (Lee, 2012), or videogames (Gee, 2007). We see students' informal digital practices as areas of strength that provide entry points into mathematical practices. Moreover, because mobiles literally travel with students as they move across the in-school out-of-school boundary, the digital artifacts that students collect and create can also move across these spaces.

Our research is in the initial stages of a design based research cycle. The work presented in this paper does not represent a "final product," and does not reach the design goal of integrating in-school and out-of-school mathematical practices. Instead, it offers an exploration of the potential of mobile devices to support bridge-building between informal and formal mathematical practices, and as such offers a platform for further research and development.

Methods

Participants and Research Site

The study took place in a diverse urban school which serves a largely low income student body (86% are eligible for free or reduced price lunch). A mixed-age group of 19 sixth through eleventh graders participated in the study for one hour per day over a two week period. The school emphasized project based learning in several areas of the curriculum, but mathematics was taught traditionally. Students participated in lieu of their homeroom period.

Design and Procedure

In overview, the study proceeded as follows. Each student was loaned an iPod Touch for the duration of the study. They were encouraged to take the devices home with them and to customize content and settings as they saw fit. We began the study with activities designed to orient students to the devices and their capabilities, especially with regard to the four characteristic informal digital practices we identified: *capturing and collecting*; *communicating and collaborating*; *viewing, consuming, and analyzing*; and *representing and creating*. During the first week of the study, we placed mathematical content first, focusing students' attention on linear equations and linear phenomena. We then asked them to collect photo and video examples of linear variation, using their devices, to bring into the classroom context (see below for more detail). During the second week, we let students' interests lead. We asked them to conduct a mathematical investigation of their own choosing, using their devices to collect and analyze data, to collaborate with peers, and to represent their results.

Results

An initial question in our analysis was, how effective were the devices in bridging students' informal (out of school) and formal (in school) experiences? The devices themselves were part of a school-based intervention: would students treat them as school-like devices, or would they modify and customize them as they might their own devices? We found some evidence that students easily bridged the dual purposes and possibilities for the devices. Of the 220 photos that students took with the devices, two-thirds were personal photos, with the remainder taken as part of school-based activities. The same ratio held for the 52 videos that students took. About half of the students customized their device by changing the background photos and/or downloading an app.

Second, we asked whether students saw the mobile devices and activities as supporting them in learning and doing mathematics. In an anonymous survey at the end of the two weeks, students were very positive about their experience. All students agreed or strongly agreed with the statement, "I learned some new ways to use an iPod during these activities," and 14 of 15 respondents agreed or strongly agreed with the statement, "I learned some new ways to use math during these activities." Data from interviews suggest a similar pattern, where students felt that they learned new ways to use the devices that supported mathematical thinking and learning.

We also looked for evidence within the activities themselves that students were able to actively participate in tasks that asked them to work across the in-school out-of-school boundary. We now turn to a brief description of one such activity that took place during week one, on day three of the study. Students were given the assignment of taking their devices home or into the community and taking a photograph of something that showed a line. When they returned to class, they used an app to send the photo to the researcher's computer (and to a classmate, if they chose to). The second author, White, who was leading the activity that day, chose a photograph of window blinds to project onto the whiteboard (see Figure 1). He then used a white board marker to draw a line superimposed on top of the image, following one of the white lines in the image.

The front of the room computer and projector were reset to display a shared coordinate plane from the *Graphing in Groups* classroom network software on the whiteboard (White, Wallace, & Lai, 2012). In dyads, students loaded the *Graphing in Groups* client app on their devices. This allowed each student in a dyad to control one of the two points that jointly define a line. Their task was to construct a line that matched the line drawn on the whiteboard, representing the line from the image of the blinds (see Figure 1).

The teacher/researcher (White) then asked students, "What do you notice about those equations that's different from these equations," pointing to equations from the previous session that had whole number coefficients on the *x* term. One student replied, "They're wholes," and then when prompted to clarify, "they're fractions." White then began to circle the equations for the various lines that student dyads had made, naming them as he went and writing them on the board: y = 1/18x + 1.53 ; y = 1/5x ; y = 1/10x + 2.5 ; y = 1/10x + 2.

The variety of fractional coefficients (less than one) provided a set of near contrasts for students to compare. These were then, in turn, contrasted with lines with coefficients larger than one. The mapping between the equations and their graphed lines, represented multiply on screen and on the board, provided the context for a discussion of the correspondence between slope of a line and the size of a coefficient. Within this instructional context, students had a context for interpreting the slope (angle of the blinds), and knew the source of the variants (themselves and their classmates). The activity culminated in a discussion of the "rise over run" interpretation of the slope, an idea that was familiar to some, but not all of the students in the mixed age group.

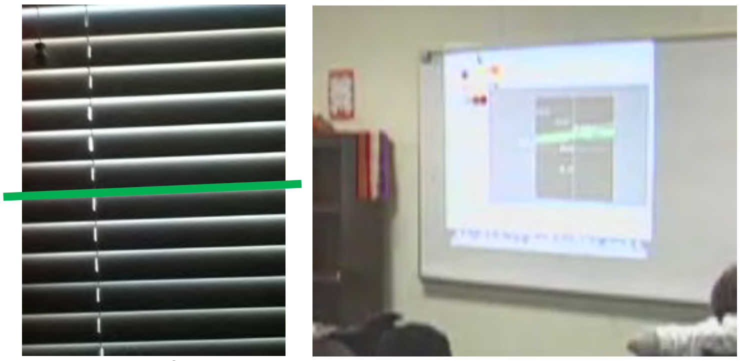

Figure 1. On the left, a student's photo of blinds, with a line superimposed in green. On the right, a *Graphing in Groups* coordinate plane projected on the board, so that students could try to match the drawn line.

Three things are evident from this activity. First, there was variation in the lines that students created to match the drawn line. In some school math contexts, this variability would indicate error, lack of precision, and need for correction. In this case, the minor variations were not problematic, likely because of the informal nature of the stimulus (a student's photo) and the approximate nature of the line matching activity. As such, the variability could then be seen as a resource – students generated similar but contrasting exemplars, and the teacher could help the class to abstract over these variations (in coefficient) to induce the relevant invariant properties (the correspondence between coefficient and slope). By creating space for student-driven variability, not only in the lines drawn but also in the photographs taken, there was greater opportunity for abstracting over cases.

Second, students had opportunities to contribute to the activities in ways other than speech. Even in this brief example, students contributed in three ways: by taking and sharing photos, by drawing lines with *Graphing in Groups*, and by raising their hand to speak.

Third, the activity transitioned easily into a second iteration. For the following day, we asked students to take a brief (10 second) video of something that they thought was changing in a linear fashion. In small groups, students segmented their videos into one second increments, measured the displacement of the relevant object, recorded the time and corresponding displacement in a data table (within a spreadsheet application on the device), and finally created a graph of the motion. As a whole class, students shared and discussed their videos and the corresponding tables and graphs. Discussions included whether or not the motion was linear and, if so, what the slope, intercept, and equation of the line would be. Here the notion of slope was generalized beyond its visual interpretation (i.e., steepness) to represent rate of change.

Discussion and Conclusion

We make no claim that the activities we present here represent an ideal or optimal learning environment. Instead, we argue that our data offer a proof of concept that mobile devices, properly deployed, can help provide technical infrastructure to ease the process of making connections between the informal competencies that students bring with them to school, and the disciplinary competencies that schools most hope to foster. As such, our findings provide warrants in support of further study of mobiles as bridging devices. Our work in this area continues as we move to incorporate more complex and substantive issues from students' lives into the mathematical work of the classroom.

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Reflectively Prototyping a Tool for Exchanging Ideas

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Abstract: We describe our approach to prototyping an iteration of the Idea Manager, a tool integrated into an online science inquiry environment. Students use the Idea Manager to track ideas as they encounter new information, and reflect upon, sort, and distinguish ideas toward integrating their understanding. To explore the value of collaborative features, we designed a hybrid online/offline activity to facilitate students exchanging ideas with the Idea Manager. Based on student interviews and case studies, we identify aspects of collaboration to inform design features for enabling the meaningful exchange of ideas. Whereas most design accounts focus on the evaluative role of prototyping, this study highlights its reflective use, and its role in involving multiple stakeholders in rapid iterative cycles of establishing requirements, building alternatives, and testing. By documenting these iterative design activities, this study informs both the theory and practice of designing collaborative educational technologies.

Reflective Prototyping and the Knowledge Integration Framework

Prototyping can inform both the theory and practice of designing collaborative learning technologies: It encourages reflection and enables early feedback from users (Saffer, 2010; Schon, 1990), serves to externalize and support the development of ideas, and helps filter aspects of interest for investigation (Lim, et al., 2008). But educational technology design tends to be practically rather than theoretically driven (Bennett & Oliver, 2011), and researchers rarely document these mid-stages of their design processes, or else they focus on the evaluative rather than on the reflective functions of prototypes (Lim, et al., 2008).

We describe how prototyping allowed us to filter and study aspects of students' collaborative learning to inform design iterations of a theoretically-driven technology: the Idea Manager. The Idea Manager is a tool integrated into the Web-based Inquiry Science Environment (WISE, wise.berkeley.edu) and designed to support students building evidence-based explanations during online science inquiry units (see Figure 1).

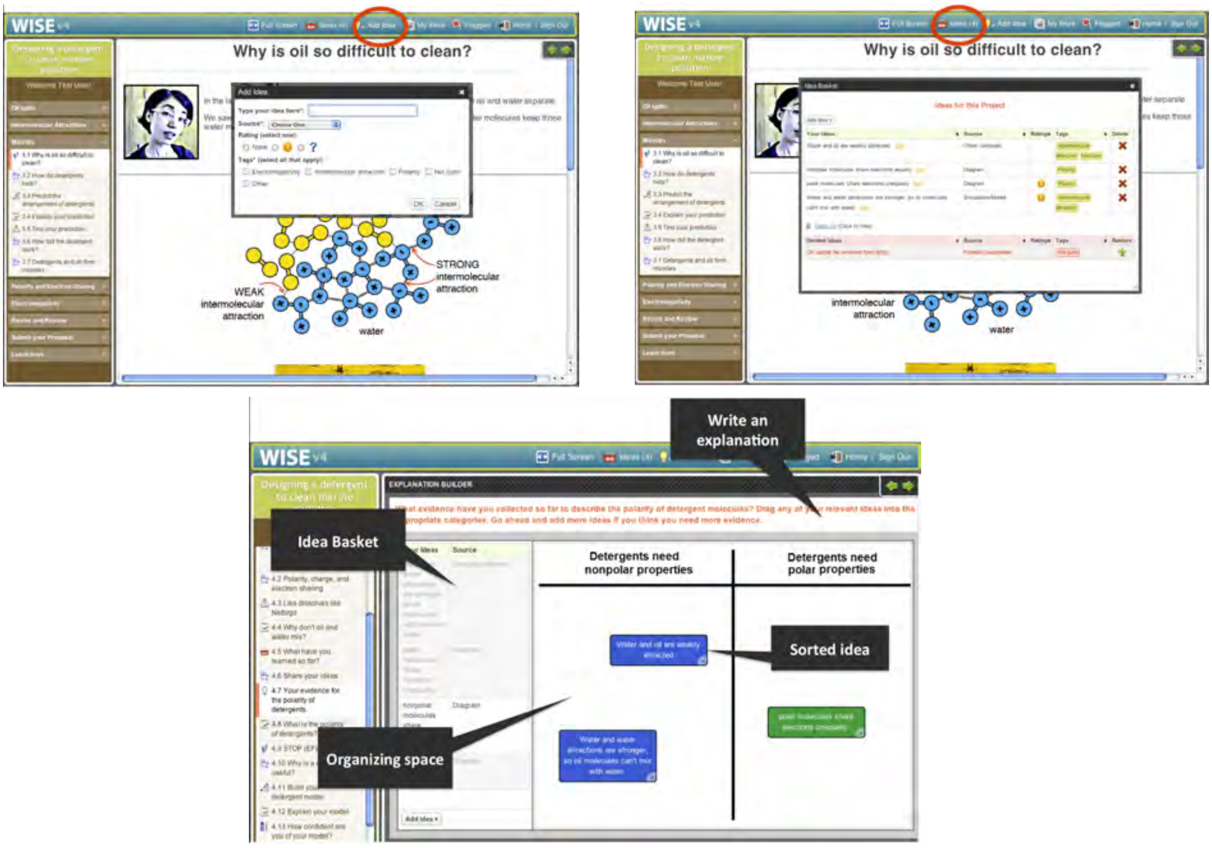

Figure 1. The Idea Manager's two components: (1) A persistently accessible repository for ideas, into which students type and revise entries (<150 characters) and apply author-supplied tags and labels (top left and right);

and (2) A dynamically linked Explanation Builder space, into which students drag and sort ideas into author-specified categories before writing an explanation (bottom).

Building on previous educational technologies (e.g., Bell, 1997, Zhang & Quintana, 2012), the Idea Manager helps students manage complexity and support production (Blumenthal, 1991). It breaks down the process of explanation into the discrete steps of gathering, sorting, and distinguishing information encountered; and guides understanding by making the process of reflection explicit, deliberative, and continual (Beeth, 1998). The Idea Manager's design is guided by Knowledge Integration (KI, Linn & Eylon, 2011), a constructivist pedagogy that takes a knowledge-as-elements perspective on learning to incite conceptual change (Özdemir & Clark, 2007). Recognizing that their existing understanding may be fragmentary and idiosyncratic (diSessa, 1993), KI instruction elicits students' prior knowledge and encourages them to confront and distinguish among their often conflicting ideas. Classroom implementations demonstrate the usefulness of the Idea Manager for eliciting and making visible students' ideas (Matuk & King Chen, 2011). Logs of students' interactions with the Idea Manager moreover lend insights into how students integrate ideas over the course of a unit, and inform targeted curriculum revisions (McElhaney, et al., 2012).

Methodological Approaches to Exploring Requirements for a Collaborative Tool

Our design process integrates user-centered design and Agile Methods of software development (da Silva, et al., 2011), and emphasizes rapid iteration between establishing requirements, designing alternatives, and building and evaluating prototypes. Through the early and regular involvement of users, this approach permits simultaneous exploration of how users and the establishment of technical and pedagogical requirements. Thus, we first elicited ideas from WISE users worldwide, including 20+ middle and high school teachers, and 30+ WISE researchers and WISE developers. Interviews, discussions, workshops, and a survey revealed interest in extending the Idea Manager to support student collaboration. Respondents saw potential in the tool for students to practice communication; for studying the impacts of peer exchange on perceptions of science inquiry; and for operationalizing and researching knowledge exchange. This investigation also revealed open questions over how to orchestrate the sharing of ideas. Should students see the ideas of all their peers, or of selected peers? Should contributing and/or citing others' ideas be anonymous or rewarded? Should teachers facilitate the exchange of ideas, and if so, how? One way to investigate these questions is to implement and observe students' use of collaborative features. But this technology-first approach risks masking the incidental face-to-face collaborative interactions that can be valuable for learning. Instead, we chose a learner-first approach, and designed an offline activity in order to identify incidental aspects of face-to-face collaboration, which would then inform specific design features in a collaborative learning tool.

Methods: The *Detergents* Unit and Collaborative Idea Manager Prototype

We integrated the Idea Manager into *Designing a detergent to clean marine pollution*, a freely available unit authored in the Web-based Inquiry Science Environment (WISE, (http://wise.berkeley.edu/webapp/vle/preview.html?projectId=4369). In the unit, students explore the chemistry of detergents and use the Idea Manager to gather and distinguish ideas on electron sharing, electronegativity, and polarity, before writing explanations for how detergents cleans birds endangered by marine oil spills. To explore the potential for a collaborative Idea Manager, we designed an *Idea Exchange* activity, which prompted students to share the contents of their Idea Baskets with another student team; identify ideas that were the same and different between their Baskets; suggest ideas to the other team; and label newly added ideas as Important or Not Important.

Participants were 170 students of five teachers at a high school in the United States. Student pairs worked on the *Detergents* unit for 5-6 consecutive school days while their teacher and a researcher circulated to offer assistance as needed. Data include classroom field notes, videotapes of nine pairs of student dyads during the *Idea Exchange* activity, and end-of-unit interviews with 15 students (2-3 students per 15-20-minute session), in which we asked for students' impressions of the unit, of the utility of the Idea Manager, and their experiences during the *Idea Exchange* activity. Our video analyses identified incidents during the *Idea Exchange*, in which collaboration appeared to promote KI (e.g., when students contributed new ideas and engaged in distinguishing among them). Our interview analysis characterized students' perceptions of the value of the *Idea Exchange* activity, and of a mediating technology. Below, we illustrate three aspects of collaboration that emerged from our prototyping, and how these informed iterations of the Idea Manager.

Major Findings

Exposure to diverse ideas through increased peer interaction

Students interviewed expressed interest in seeing their peers' ideas. As one student described, the *Idea Exchange* activity showed how the other students "saw it different than us. They would tell us 'Oh, but this...

and then we would tell them." Another student noted that "it was useful to see like how other people, like what their views of the project were, and how, what kind of notes they were taking." The *Idea Exchange* not only exposed students to different ideas, but also broadened their social encounters. One student noted "I don't talk a lot in this class," but in the *Idea Exchange*, she and her partner collaborated with peers outside their social circles. Thus, students appeared to value the opportunity to discuss divergent perspectives with their peers. Indeed, research on brainstorming and group creativity suggests that early exposure to others' ideas has positive impacts on the speed with which individuals generate new ideas, as well as on the quantity, diversity, and semantic organization of ideas generated (Nijstad, Stroebe, & Lodewijkx, 2002).

At the same time, our data revealed a number of logistic issues with coordinating the sharing of ideas. Because their work was self-paced, it was rare for a sufficient number of teams to have simultaneously arrived at the *Idea Exchange* activity, which resulted in students waiting idly for others to catch up, or else moving ahead and forgetting to later return to the activity. Some students indicated in their responses to the embedded prompts that their partner teams' ideas were too few or too similar to spur discussion. In one student's description of this "awkward" situation, a partner might ask, "'What was your ideas?' And a lot of the ideas people would write... it would be something that I probably already knew or thought of." This challenge limits the diversity of ideas students encounter, and forfeits chances to learn from one another (cf. Hsi & Hoadley, 1997). To increase students encountering diverse ideas, a text-analysis function might help automatically partner teams based on similarities or differences of their ideas. This same feature might help coordinate asynchronous participation, and eliminate the time students spent idly waiting for others to catch up.

Orchestrating Meaningful Sharing of Ideas

Face-to-face, students not only present their ideas, but benefit by questioning, explaining, and elaborating upon them (Howe & Mercer, 2012). For example, when one student pair questioned another's use of the term *electron sharing*, the teams proceeded to negotiate a shared conceptual understanding (see Figure 4, left). Students are themselves conscious of the value of face-to-face sharing. On being asked whether she would prefer to exchange ideas face-to-face or online, one student replied "it's always better like, face-to-face, because that's when you actually discuss the main topic, and it's just not reading it, and (...) just putting it in your Basket to get more ideas." Yet, we observed face-to-face interactions in which discussions failed to develop beyond dictating entries for others to transcribe (see Figure 4, right). A digital platform would easily avoid the need for dictating entries, but it must also encourage careful consideration of one another's ideas. Threaded, scaffolded discussion around individual entries, for example, might encourage and capture more elaborated discussion (cf. Hoadley & Linn, 2000; O'Neill & Gomez, 1994).

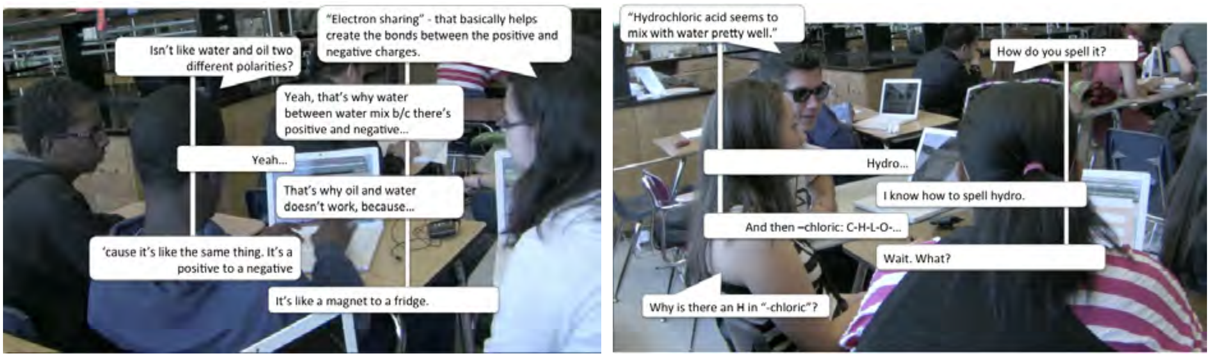

Figure 4. The *Idea Exchange* activity engaging students in distinguishing ideas (left), and devolving into a dictation exercise (right).

Vulnerability, Validation, and Social Exclusion

Sharing unrefined ideas puts one in a state of vulnerability, and how the recipient responds can have either alleviating or worsening effects. In one case, Vitaly apologizes to Harshan because he and his partner have collected only one idea, and, he adds, "I don't know if it's right." Harshan replies, "That's a good idea," and reminds Vitaly "It's an idea. It's not right or wrong, it's just an idea." Pointing out "We both agree that the atoms don't have a strong attraction so they won't bond together," Harshan then leads a conversation to further elicit and distinguish each of their ideas. In a contrasting case, Elliott shows visible dislike for Armando, and tells his partner Derek, "I'm not talking to him." Instead of engaging Armando, Elliott and Derek work alone to answer the unit prompts as Armando silently faces away from them. Once finished, Armando abruptly picks up his laptop and returns to his desk. These episodes demonstrate a range of social dynamics and their implications for learning. Whereas Harshan's validation of Vitaly's ideas shows how collaboration can encourage meaningful sharing of ideas, Elliot, Derek, and Armando's failure to achieve intersubjectivity results in a missed learning opportunity (cf. Barron, 2003). Technology might anticipate these outcomes by allowing anonymous participation, thereby foregrounding ideas and promoting contributions (cf. Hsi & Hoadley, 1997).

Conclusions and Implications

Our prototype highlights the value of peer interaction for exposure to diverse ideas; the impacts of favorable and adverse social dynamics; and logistical considerations for orchestrating the meaningful exchange of information. Without attempting to identify broad generalizable patterns, these cases illustrate the spectrum of collaborative interactions afforded by face-to-face and technology mediated collaboration, and define a baseline for further study. By documenting the co-evolving design and development of a theory-driven tool, this paper informs both the theory and practice of designing collaborative learning technologies.

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Visualizing Topics, Time, and Grades in Online Class Discussions

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Abstract: We present a series of visualizations of online discussions that combine topic modeling with other dimensions of the discussion contributions, to help faculty assess and improve learning from discussions. After applying probabilistic latent semantic analysis (pLSA) to calculate the relative conceptual distance between discussion posts, we projected posts or collections of posts into a two-dimensional space. By color-coding points according to their temporal position in the course or according to the author's final grade, we captured patterns in students' contributions that connect the topic modeling factors to more intuitively familiar characteristics. We consider how some possible qualitative features of the discussion may be represented in the topic space and outline future work to develop these tools further.

Introduction

As usage of class discussion forums has grown in both online and blended courses, so has the need for effective tools to monitor and interpret the activity in those forums. Just as they do in face-to-face environments, faculty must recognize teachable moments and facilitate effective interaction, but mediated by text-based, asynchronous communication. With this challenge also comes an opportunity: Using automated machine intelligence to mine the discussion record for key patterns may streamline the reading process, enabling faculty to focus on the most critical and valuable opportunities to intervene.

Existing applications of text mining to discussion forums have incorporated a variety of visualizations and features to guide users in navigating those discussions (*e.g.*, Awuor & Oboko, 2012; Kim, Shaw, Ravi, Tavano, Arromratana, & Sarda, 2008; Faridani, Bitton, Ryokai, & Goldberg, 2010). Yet much of this work focuses on the student or primary discussion participant as end user, rather than targeting the needs of an instructor seeking to facilitate a discussion to meet particular educational goals. In addition to obtaining a quick read on major themes and disagreements within a discussion, faculty need to assess students' understanding of key concepts, the quality of their participation, and their progress toward course goals. Addressing these disparate needs together in an integrated environment can help faculty keep students on track while also encouraging broader exploration. The work presented here offers a proof-of-concept using text mining to create visualizations linking formative and summative assessment to help faculty support productive online discussion.

Background

Text mining methods include numerous statistical techniques to identify patterns in a large body of text. Our focus here is on utilizing topic modeling to examine the semantic content of discussions, rather than incorporating syntactic, linguistic, stylistic, or sentiment analysis. Topic modeling analyzes a collection of documents to discover the topics discussed in those documents, as represented by a set of weighted terms (Deerwester, Dumais, Furnas, Landauer, & Harshman, 1990). One type of topic model, probabilistic latent semantic analysis (pLSA), analyzes the probability of word co-occurrence in a given document, assuming Gaussian distributions of topics and word likelihoods (Hofmann, 1999). It treats each document as an unordered "bag of words" and infers a small set of latent factors which explain the distributions of words across documents. Each latent factor is a list of co-occurring words (a topic), and each document may be represented as a weighted combination of those factors (or topics).

For simplicity and proof of concept, we applied pLSA rather than one of the many more sophisticated topic models available (*e.g.*, latent Dirichlet allocation, LDA, and its variants). In previous related research, we used pLSA to create topic space visualizations depicting the relationship between students' posts and the instructor's posts, demonstrating the feasibility of the technique for revealing key patterns in their discussion interactions (Ming & Baumer, 2011). Other research successfully predicted students' course grades by applying pLSA and hierarchical LDA to their discussion posts (Ming & Ming, 2012). Here we connect discussion patterns with course grades to better illuminate important trends as the discussion unfolds, so that instructors may intervene to guide individual students or particular discussion threads. Future continuations of this work will explore how other models, algorithms, and visualizations may improve upon the results obtained here.

Methods

We examined student data from the discussion forum of an introductory, undergraduate-level biology course in the online degree-granting program at a large, for-profit university. Students were typically expected to post at least two substantive responses to each of two discussion questions per week, throughout all five weeks of the course. While individual instructors were granted some freedom in selecting the specific questions and assignments, each course instance (class) was required to adhere to a standard course outline and schedule with regard to learning goals, topics covered, and texts used. For this project, we restricted our analysis to students' contributions to the main discussion forum alone rather than including instructors' comments; conversations in individual and group discussion forums; or students' work on assignments, quizzes, projects, and tests. Later analyses incorporating these additional data from students, instructors, and other normative sources may further enrich our picture of student knowledge as evident from text.

Our analysis focused on 17 distinct classes taught by four instructors previously studied in other related research (Ming & Baumer, 2011). We normalized grades to be between [0,1] and removed data from students who dropped out before earning a final grade, to avoid confounding the quantity or assigned topics of their text with more subtle features associated with grades. This yielded a final dataset of 9118 posts by 230 students taking the same course within approximately a one-year interval. Posts were tokenized using a novel method called phrasal pursuit, which learns statistically meaningful phrases of arbitrary length. Phrases which occur regularly in the student posts and improve the pLSA model likelihood (described below) are incorporated into the bag of words/phrases representation. It uses model fitness rather than pairing likelihood as its selection criteria. For this method, we produced a dictionary of 5495 phrases.

Using pLSA, a probabilistic, generative extension of standard LSA, concepts/topics emerge as generative factors inferred from the documents by maximizing the data likelihood via gradient methods. A post with multiple topics is represented as the additive combination of multiple factors, and each factor is, in turn, a representation of a specific correlation pattern between the 5495 phrases in our dictionary. For our application of pLSA we assumed 100 topics/concepts from the discussion. After training the model to uncover the latent topics/concepts in the student posts, we used it to visualize the student work in 2-dimensional concept spaces. Posts or collections of posts were "projected" into 100-dimensional concept space by inferring the pLSA factors present in the writing (*i.e.*, computing the non-zero factor coefficients by gradient descent). For all of the projected documents we then used local linear embedding (LLE) to find a 2-dimensional representation which maximally preserves the spatial relationship between documents in 100-dimensional space.

Additional qualitative analyses drew from prior case studies characterizing the interaction patterns and discussion quality in selected threads reflecting a range of facilitation styles (Ming & Baumer, 2011).

Results and Discussion

The results in Figure 1 show that pLSA-based topic modeling may be used to capture some of the semantic differences in the discussion posts of students who receive different grades. In this graph, each point represents all of the comments by one student, color-coded by the student's final grade in the course. The aggregated posts from each student were first "projected" into the 100-dimensional pLSA concept space, and then LLE was used to further reduce the representation of the student's writing down to two dimensions. The horizontal gradient showing grades increasing from left to right suggests a machine-detectable difference in the topics they discuss. The vertical dimension reveals that students receiving C's and lower appear to neglect certain topics, represented below the dotted line. Closer examination of individual students' posts and of the topics and terms that correspond to these two axes will be invaluable for helping to interpret what these differences mean and how an instructor might potentially intervene to address them.

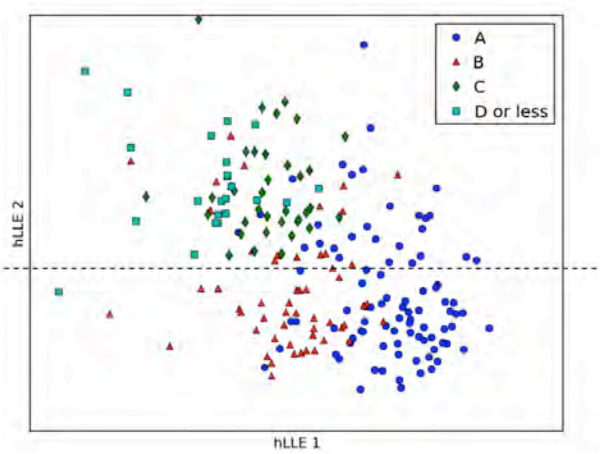

Figure 1. Topic space projection showing posting regions by individual students, color-coded by final grades. Each point corresponds to one student and represents all posts by that student in the main discussion forum.

Examining the discussion by individual posts rather than aggregated by student offers additional insight into some of the differences associated with course grades. As before, the axes in these figures were chosen for maximal separation rather than inherent meaning, so shorter distances between points reflect greater similarity between posts. Figure 2a shows that discussion posts by students earning grades of D or less are clustered in the center of the graph with little differentiation among them. As course grades increase, the associated comments travel farther away from the center, suggesting that these posts are exploring more specific topics. These results are consistent with our earlier finding, upon applying hierarchical LDA to data from a different course, that students earning higher grades discuss more specialized topics, while students earning lower grades discuss more general topics (Ming & Ming, 2012).

It is worth noting that this representation provides only a simple two-dimensional projection of the data. The results from the two figures combined indicate that there are multiple dimensions along which discussion comments and course grades covary, with comments moving toward the lower right corner in Figure 1 and diverging from the center in Figure 2a as course grades increase. The additional structure evident in Figure 2a further reinforces that there are specific directions in which higher-earning students' comments are moving, possibly corresponding to instructors' questions and comments or other aspects of the course structure. This suggests that students earning higher grades are not simply discussing topics with greater depth or specificity, but are addressing particular concepts that may be worthwhile.

One possible interpretation of Figure 2a's central cluster of posts by students earning low grades is that those students gradually stopped participating later in the course, and that region may contain the most basic concepts from the beginning of the course. However, coding the discussion comments according to course week reveals that the different weeks of the course correspond to the separate branches of the graph, as shown in Figure 2b. This could reflect the shift in topics as designed in the course outline, or the particular discussion questions that were asked. The different patterns produced by the two color coding schemes suggest that students earning lower grades tend to remain in the central, most general region even when the course topics invite more specific comments by students earning higher grades.

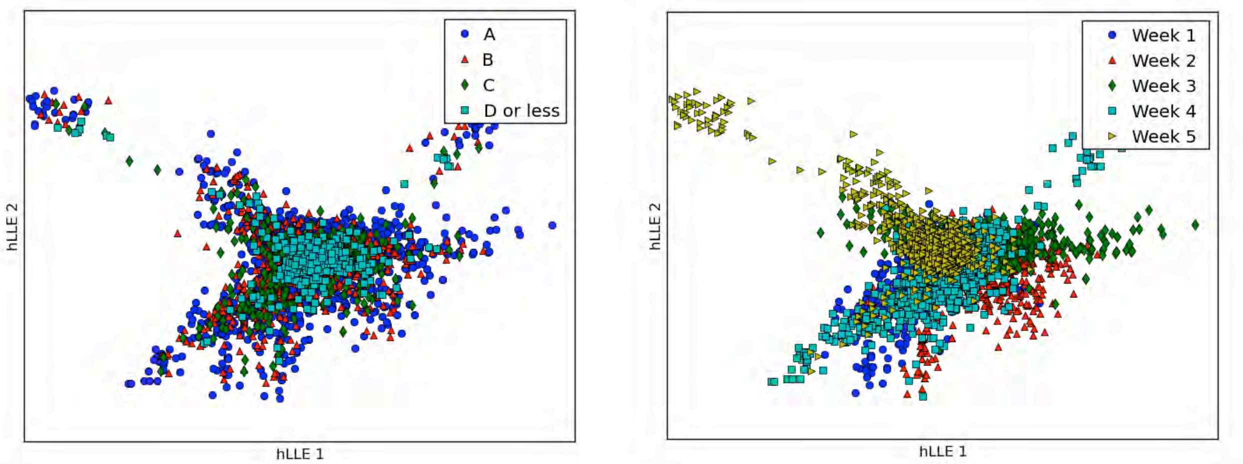

Figure 2. Topic space projection showing individual posts. The graph on the left (a) is color-coded by the final course grades earned by the post author; the graph on the right (b) is color-coded by course week.

Closer reading of individual comments and discussion threads suggests several worthwhile dimensions to examine for their potential correspondence with the axes shown in these topic space projections. While posts that are more distant from the center show more specificity and tend to come from students earning higher grades, those posts do not necessarily all contain comparable quality or educational value, regardless of the final grades earned by the students who authored them. Specificity is a correlate but not a guarantee of higher grades.

Greater specificity could potentially reflect a particular instantiation of a concept, a previously underemphasized step in a causal chain, a related fact, a personal anecdote, or a discussion of implications. One question described how disruptive evolution could lead to speciation and asked students to provide a new example of the same phenomenon. Here, conceptual distance may reflect the extent of overlap with the initial example and other students' examples in the type of organism, the feature mentioned (*e.g.*, animals' coloring), or the causal mechanism (camouflage and predation). Insofar as these dimensions vary in their importance, they also reveal that increased hierarchical depth may not always correspond to deeper understanding.

Likewise, despite their specificity, interesting related facts and personal anecdotes may be relevant or instructive in some cases but not in others. How closely they match other posts in the discussion offers no guarantee of their educational value, since they may spawn off-topic digressions or nuanced explorations of key concepts. Deciding when a conversation about identical twins shifts from pondering fundamental questions of nature-*vs.*-nurture to sympathizing about childrearing challenges demands deeper reading to identify distinguishing features.

Causal explanations and implications may be more likely to include topically relevant and illuminating discussion that advances student understanding. For example, articulating whether and how acquired traits might be inherited can prompt further exploration of how natural selection works. Similarly, identifying the energy source that drives capillary action in plants can help elucidate the underlying mechanism. Contemplating whether some populations might no longer be evolving or how hydrogen bonding affects water movement can also encourage deeper reflection on the biological and chemical processes involved. In these situations, addressing non-normative ideas may still be beneficial, by helping students to consider their ramifications and re-evaluate their own thinking.

These possibilities highlight the need for expert human judgment when intervening. Distinguishing among and mapping them to the dimensions on the topic space requires further work to link the qualitative analysis to the quantitative features from the hierarchical topic modeling. In particular, locating normative ideas within the topic space will provide valuable anchor points for tracking discussion trajectories. Continued analysis of how key concepts and misconceptions map on to the patterns evident here will further clarify the relationship between the topic modeling factors, students' grades, and their response to instructor intervention.

Conclusion and Implications

This work demonstrates the potential for applying topic modeling to generate insightful visualizations of student discussions that connect features of individual comments with later course performance. The selections shown here provide just a few early illustrations of how topic modeling can help to reveal the depth or sophistication of the concepts being discussed, as well as their correspondence to the desired topics and learning goals as designed in the course. At its most primitive, such work can analyze discussion post content to flag students who are likely to score poorly at the end of the course. More interesting applications can offer clues to content-specific reasons underlying those outcomes and suggest actions to influence learning trajectories. Creating a map of the topic space that includes normative sources (*e.g.*, the textbook, other required reading materials, instructor's lecture notes and comments) would help enable such identification. With such a guide, instructors then could quickly recognize when a particular student might be neglecting to consider some key concept, or when a discussion thread might be mired in a confusing misconception.

As a tool to help faculty monitor online discussions more effectively, such visualizations harness the power of machine intelligence to serve up potentially useful information for further evaluation and action by human intelligence. During their development they will need to be evaluated not just for their ability to capture important characteristics of student knowledge, but for their ability to convey useful and actionable information in an understandable manner. Future research will help determine how well tools based on these analytical techniques correspond to and augment instructors' professional knowledge.

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Digital Scholarly Storytelling: Making Videos to Explain Science

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Abstract: Digital scholarly storytelling or digital storytelling in the service of explaining science is currently a blip on the radar of higher education and research on this mode of instruction is hard to come across. This paper reports quasi-experimental research conducted in a higher education nutrition science classroom in Fall 09 and Spring 12. Students participated in a multimedia creation project as an integral part of the course, whereby they collaborated in small groups to create video PSAs about a topic of choice. In order to develop this project, students underwent digital research and multimedia training sessions. They answered pre and posttest surveys about their attitudes and self-reported abilities with reference to digital literacy and multimedia skills, and participated in focus group interviews to discuss their experiences in detail. Survey results show an improvement in their understanding of copyright information and multimedia skills, and focus group interviews underscore the many enjoyable and frustrating aspects of the process. Pedagogical implications are discussed.

Introduction

Student-created video projects involving collecting and presenting video data or telling a scripted story using original footage, music, graphics, animations, etc. have often been studied for their pedagogical abilities. For instance, middle school students in Egypt were taught to use Microsoft Photo Story© to create videos related to any topic of their choice (Sadik, 2008), 10 year old English children were taught to use digital editing software and they created stories related to their school (Pearson, 2005) or college student made podcasts on topics related to Information Technology (Lee, McLoughlin and Chan, 2008). However, the use of digital video in education is woefully under researched, particularly that which is integrated within the established or mainstream curricula (Pearson, 2005 and Lippincott, 2007). A quick review of literature shows that there's a paucity of research about the use of this tool for *scholarly* storytelling, i.e. explaining existing research about a specific topic using original footage, music, graphics, animations, etc. The primary examples of such creations are commercially produced videos, documentaries or digital shorts, but those produced by students are rarely discussed in the literature. For instance, Nixon (2009) describes a digital storytelling project of bilingual high school students where including data was a personal choice, the project was extra-mural and Nixon does not explain if and how students were trained to use the tools of digital and multimedia literacy- something of crucial importance to multimedia creation in education (Lippincott, 2007). In this paper, we discuss a collaborative scholarly storytelling project about nutrition science in a higher education classroom, along with the process by which we prepared students to take on the challenge of translating scientific research into an accessible video PSA.

Student groups in Nutrition 360 are required to create a video PSA on any topic related to nutrition for which they shoot original footage and edit it digitally. A unique inter-institutional collaboration between the instructor, the university's media and technology support unit, and the university libraries sustains this project. The goal is to facilitate students' digital scholarly storytelling i.e. research that is translated and visualized in an accessible manner in the form of a video. The project was studied in Fall 09 and Spring 12. Student feedback in the first iteration drove changes on several counts, discussed in detail later. We were curious about how the digital and library research and multimedia training affected students' perceived abilities and attitudes in every iteration, and what the differences between iterations were, if any. Hence, the research questions for our study were as follows:

i) How does library training affect students' perceived abilities and attitudes toward finding and using digital library resources or other online information sources for class assignments?
ii) How does multimedia training affect students' perceived abilities and attitudes toward creating multimedia for class assignments?
iii) How do changes between two semesters affect
   a) Students' perceived abilities and attitudes toward finding and using digital library resources or other online information sources for class assignments?
   b) Students' perceived abilities and attitudes toward creating multimedia for class assignments?
iv) How do changes between two semesters affect students' experience of learning to, and designing and developing the project?

Data for this study relied on two instances of training: the library training session covered the library's website as well as other online research sources and the multimedia training session covered using iMovie, the digital editing software, and conducting research for a video. The outcome of the project was a short digital video (up to 1 minute long in Fall 09 and up to 2 minutes long in Spring 12) by each student group, published on Youtube™. Topics included the effect of smoking on nutrition, cooking at home versus eating out, hydration for athletes, daily required protein intake, iron consumption for women, etc. Data was collected using identical pre and posttest surveys and focus group interviews. The survey consisted of 20 questions asking them to identify their previous research and multimedia training, online behavior, attitudes toward and knowledge of digital and library research and multimedia creation. Results were analyzed statistically. Also, in groups of 7-12, students were asked to recount their experience of the process, positive and negative aspects and suggestions for change. These interviews were recorded, transcribed and analyzed qualitatively.

Results and Discussion

Findings from the survey and focus group data are explained here, starting with major themes from the focus group interviews with supporting quotes, followed by a discussion of each research question using survey and interview data.

Focus Group Results:

Although many students were unfamiliar with Macs as well as iMovie, they enjoyed learning a new skill. Editing too was a frustrating but 'intellectually satisfying' part of the process.

> "I liked learning iMovie. I didn't know anything about it before. I think it was really beneficial for me because I can use it later on in life if I ever need it." (Spring 12, Focus Group 3).

They also liked learning to create a video for class as an alternative to writing a paper and as a life skill, especially because they could share it with others.

> "...because you hope that cooking something healthy is better than going to McDonalds and so it was kind of like a test and the fact that it actually came out to be true was really like cool to see." (Spring 12, Focus Group 1).

Several problems cropped up due to a lack of experience using Macs, iMovie and video cameras and in many cases, one or two students handled the editing.

> "And I thought it was hard to split up the actual editing of it because we had one group member who did basically all of it and that was because the rest of us weren't as proficient in the iMovie program, so that was kind of frustrating because I felt we kind of unloaded that all on her and weren't able to help." (Spring 12, Focus Group 1).

For a vast majority of students, research was a small part of the process due to the widely held belief that since the PSA was for laypeople, it had to be simplistic. In addition, students believed that a written paper is deserving of in-depth research more than the video.

> "… if you're writing a paper you need to be able to support everything that you're saying pretty much. But this was like just kind of the facts and then you can present them quickly." (Fall '09, Focus Group 3).

Group work was a frustrating experience for many due to difficulty aligning schedules, although the instructor offered some free class periods in which to work together. Students in Spring 12 had twice as long in which to tell their digital story as students in Fall 09, primarily due to the negative Fall 09 feedback. They had mixed feelings about the schedule of iMovie and library training as well as the pre-shooting deliverables.

> " … it (the iMovie training session) was like so far ahead of when we actually did the editing that you didn't really remember it anyway . If it had been like a couple days before, like the week before I think it would have been much more effective". (Fall 09, Focus Group 6).

They were surprised to learn about copyright information.

> "... I thought that was really informative because I think our group probably would use some type of music off blind like from iTunes or something else with no idea that I--you know you couldn't do that." (Fall '09, Focus Group 1).

Discussion by Research Question

1) How does library training affect students' perceived abilities and attitudes toward finding and using digital library resources or other online information resources?

Knowing *how to "find multimedia resources for class assignments"*, "*use the library's website to find books, articles, etc*." and *confidence in finding books, articles, websites* all showed a significant difference between pretests and posttest of Fall 09 and Spring 12. Of the variables *not* showing significant differences were the ability and value of finding and using information- particularly reliable, trustworthy information- for class assignments, knowing how to use online information for the same and understanding copyright and ethical use of information. Each had above average scores. Although this result seems to suggest that the library training did not teach students anything new about finding reliable and trustworthy information, copyright and ethics, focus group interviews showed that this was not so and that, in fact, this information surprised students. High pretest scores actually show a mistaken confidence in their understanding of the matter *before* the library training and high posttest scores indicate a now-justified confidence in their ability to find and use appropriate information.

2) How does multimedia training affect students' perceived abilities and attitudes toward creating multimedia for class assignments?

Four variables referring to the ability and confidence in using multimedia software such as iMovie to create videos for class assignments showed a significant pre-test to posttest difference in Spring 12. All except '*creating multimedia for class assignments helps me better understand course concepts'* showed such a difference in Fall 09, one possible reason being that students believed that the necessity of creating an easily understood PSA required them to depend on familiar facts and sources, resulting in lost learning opportunities. This was an undesirable outcome that requires a change in teaching strategy to equip students to incorporate in-depth research in their videos in order to truly accomplish the goal of the project. On the other hand, since this data did not include a performance measure, the learning outcomes are speculative rather than definite.

3) How do changes between two semesters affect students' perceived abilities and attitudes toward

i. finding and using digital library resources or other online information sources
ii. creating multimedia?

We conducted an independent t test to compare the pre and posttest results of the two semesters respectively to find differences, if any, between groups. Pretest comparison showed that students in the two semesters significantly differed from each other on eleven variables with few similarities; they scored low on their perceived ability to create videos or their confidence about the same. They also scored low on the belief that they can find everything they need through Google. This was surprising since in every survey, between 86% and 97% of the students identified themselves as frequent users of Google search.

Post-test comparison showed non-significant differences on fourteen of the seventeen variables compared, i.e. three significant differences. We found that, students' perceived abilities and attitudes toward finding and using digital information as well as creating multimedia changed over the course of each semester to become overwhelmingly similar such that the two groups differed on only three variables. Two of these were *I know how to create a video using iMovie or other multimedia software* and *I am comfortable using technology to create videos, podcasts, and other multimedia for class assignments*, with mean scores higher in Fall 09 as compared to Spring 12. Since pretest scores for the former were similar in both semesters, it is interesting that the Fall 09 group showed a stronger posttest agreement. With regard to the second variable, the two groups differed significantly in the pre as well as posttest surveys, making it harder to compare their post-test differences. Although this may create the impression that students' scores on these variables dropped in Spring 12, this comparison is in fact harder to interpret given the quasi-experimental nature of this study and the duration between the two iterations.

4) How do changes between two semesters affect students' experience of learning to, and designing and developing the project?

The two semesters differed in terms of four aspects of intervention.

a) After Fall 09 findings showed that student groups did not conduct in-depth research for their PSAs and many videos lacked citations, we incorporated research training into multimedia training to underscore its importance. Unfortunately, the belief that 'PSAs don't need research' remained dominant and we did not hear differently in the interviews of Spring 12, although in-video citations improved.
b) Students from Fall 09 complained that many did not get an opportunity to interact with iMovie during the training, since they were not seated individually. Therefore, in Spring 12, both multimedia and library training were conducted in the university's Knowledge Commons (a technology rich learning center), offering individual machines as well as a more student centric, collaboration friendly spatial arrangement, with the result that the earlier complaint was conspicuous by its absence.

c) Students in Fall 09 blamed the fact that pre-video deliverables were scheduled several weeks in advance of their video submission for a lack of psychological connection between the deliverables and the final product. So, Spring 12 saw a tighter timeline, eliciting a more mixed response from the students – particularly the positioning of spring break right before the submission date.

d) The most equivocal complaint from the students in Fall 09 was about the time limit afforded to them (1 minute). They pointed to the rushed nature of their as well as others' videos, which purportedly was a result of having to 'cram' all the information in such a short period of time. Therefore, students in Spring 12 were allowed to work with 2 minutes, with the hoped-for outcomes of more positive feedback about the new limit as well as improved overall video quality.

Pedagogical implications of creating multimedia for class

- Realizing while filming that what their storyboards would not work was an important learning experience in creating video for class and this possibility should be emphasized.
- Students may need to be advised about the time investment necessary for a video as short as 2 minutes.
- Translating academic research into an accessible story tested students' creative skills in ways not demanded by papers or presentations and introduced most to a new form of sophisticated communication.
- Creating something they could 'show' over writing or talking about it, and sharing it with their class, friends and family substantially added to students' engagement in the project.
- Copyright education was crucial in order to prevent students from violating copyrights.

Recommendations for future research

- According to Cox, Vasconcelos and Holdridge (2009), "translating book learned knowledge into visual forms involves a specific type of intellectual challenge" (p. 831), and the conditions and implications of meeting this challenge successfully need to be in the spotlight, as this study does.
- Students learned to use a new form of communication befitting a generation entering the 21st century workforce. As Daley (2003) believes, the truly literate of this century will be the ones who speak the language of multimedia. We need more research to understand how to help students be fluent in it.
- The foci of this project were content expertise, digital literacy as well as multimedia literacy, supported by a unique inter-institutional collaboration. It will be worthwhile to understand if and how it works toward improving student performance and usage of information and media facilities over time.

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How Collaboration Scripts are Internalized: A Script Theory of Guidance Perspective

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Abstract: With respect to the Script Theory of Guidance (SToG), four open questions of importance are identified regarding the optimal scripting level principle. This principle concerns mainly the interaction between internal and external scripts as well as the effect of this interaction on knowledge acquisition. In an experimental study with N = 96 participants (who learned in groups of three), we examined the effects of external scripting and fading on the development of an internal script and analyzed the role of the individual's initial internal script. The results are in line with the principles of the SToG so that the external script facilitated the internal script mediated by the application during the collaborative learning. In addition, the initial internal scripts interact positively with the external script regarding the effect on the development of individual's internal scripts.

Collaboration scripts have been used to scaffold various computer-mediated collaborations through a sequence of interaction phases with designated activities and roles (Kollar, Fischer, & Hesse, 2006), with the purpose of helping learners to engage in productive interaction and collaborative knowledge construction (Fischer et al., 2013), such as the construction of arguments. Through argumentation, students learned to think critically, articulate their own views, and negotiate their own thoughts with others' different perspectives. Despite much progress, the findings have been mixed with respect to the effects of structured instructional supports for groups (e.g., Stegmann, Weinberger, & Fischer, 2007) to foster argumentative knowledge construction. Hence, there are questions that deserve further investigation to understand the underlying principles associated with effective collaboration scripts. Recently, Fischer and colleagues (2013) outlined a Script Theory of Guidance that take a systematic view of central components that are shared among different scaffolding approaches and several leading principles to explain a broad range of findings from the CSCL literature.

The script theory of guidance describes how the learners' knowledge on collaboration can be described in terms of internal collaboration script components and how these internal collaboration script components guide learners in understanding of and acting in CSCL practices. Participation in these practices, in turn, facilitates the development of these hierarchically organized internal collaboration scripts. Four conceptual components were identified: The *Play* component constitutes general knowledge about the collaborative situation at the top level. The *Scene* components include knowledge about a specific situation in a play and the *Scriptlet* component refers to knowledge of activities and their sequence(s) in a particular scene. Finally, the *Role* components typically extend across several scenes and activities, which thereby constitute knowledge of how the activities are distributed during a scene within a group. The external collaboration script consists of scaffolds targeting at supporting the learner to employ internal collaboration script components that would not have been used spontaneously.

In addition, seven guiding principles were outlined in the Script Theory of Guidance (Fischer et al., 2013).One of the principles emphasizes the importance of being 'optimal' in regards to the degree of external collaboration scripts that are put into use *(Optimal External Scripting Level Principle)*: "An external collaboration script is most effective for knowledge acquisition if it is directed at the highest possible hierarchical level of internal collaboration script components for which subordinate components are already available to the learner." However, striking the balance between too little scaffolding to be helpful and too much scaffolding to allow for group interactions is indeed a delicate issue (Dillenbourg, 2002). Against this background, the question arises of how to further conceptualize and manipulate the vague meaning of the 'optimal' level of scripting. The highlighted dynamic nature of scripting is based on the intrinsic component of the scaffolding system called 'internalization'. Accordingly, the specificity of the external script would need to gradually be reduced to ensure that learners are not given instruction they actually do not need – a process of reducing the amount of external instruction is known as fading (Pea, 2004). Despite the fact that SToG postulates that internal and external scripts need to be optimally combined to facilitate knowledge acquisition most effectively,,the theory does not explicitly specify the role of fading for acquisition of internal scripts. A close-up analysis of how do external scripting and fading affect the internalization of collaboration scripts, therefore deserve further investigation through controlled experimental studies.

The *Transactivity Principle* outlined in the Script Theory of Guidance states that the acquisition of knowledge is positively associated with the amount of the transactive application through participation in a given CSCL practices: "The more a given CSCL practice requires the transactive application of knowledge, the better this knowledge is learned through participation in this CSCL practice." (Fischer et al., 2013, p. 58) While several empirical studies on the effects of external collaboration scripts from CSCL research show the effectiveness of external collaboration scripts regarding their positive effects on collaborative learning processes (Stegmann et al., 2007), past efforts did not lead to a unique and integrated model of the effects of collaboration scripts on the learning processes as well as outcomes. There still remains little research which provided empirical evidences for exploring the underlying relationships between the repeated application of script components and the assumed individual development of internal collaboration scripts.

From the perspectives of SToG, both of the internal and external collaboration play essential roles in guiding learner to understand and act in CSCL practices. On the one hand, "when participating in a CSCL practice, the learner's understanding of and acting in this situation is guided by dynamically configured and re-configured internal collaboration scripts." (*Internal Script Guidance Principle*), and on the other hand, "external collaboration scripts enable learners to engage in an instance of a CSCL practice at a level beyond what they would be able to without an external collaboration script." (*External Script Guidance Principle*). Shortly, external collaboration scripts can create opportunities, but whether learners benefit from the instructional supports depends on the dynamic interplay between internal factors and external instructions. Kollar (2007) reported that the success of collaborative learning is also affected by learners' internal collaboration scripts that guides them in collaborative settings. While researchers have adopted the importance of internal collaboration scripts largely for theoretical reasons, surprisingly little direct empirical evidence exists to actually verify these assumptions. The current work both divers and builds upon the previous study, rather than providing polarized treatments, either with or without collaboration scripts we explore the interplay between internal and external scripts when various degrees of scripting are manipulated.

Research questions

The purpose of this study is to build in-depth understanding of the effects of an external script on the acquisition of an internal script and analyzed the role of the individual's initial internal script. A set of research questions was formulated to address the interactive relationships between internal and external collaboration scripts.

RQ 1: To what extent does external scripting and fading affect application of internal script components during collaborative learning?

RQ 2: To what extent does external scripting and fading affect the development of an internal script?

RQ 3: To what extent is the positive effect of external scripting and fading on the development of an internal script mediated by the application of internal script components during collaborative learning?

RQ 4: To what extent is the positive effect external scripting and fading have on the development of internal script moderated by the initial internal script?

Methods

Ninety-six (N = 96) students at the University of Munich participated in this study during the summer term 2010. The collaborative learning task of the participants was to apply the Attribution Theory to five problem cases through argumentation and propose a final analysis for each case. A one-factorial experimental design with three conditions was implemented. The time on task, all together 80 minutes, was held constant for the three conditions. During the entire learning process, individuals were randomly assigned to groups of three and further to one of the three experimental conditions. In order to address the complex problem of 'over-scripting', a rather detailed external collaboration scripts in the *High Degree of Scripting* (HD) condition was developed (at the bottom level of *Scriptlets* targeting the specific activities). For instance, written prompts were delivered according to a simplified version of Toulmin's model (1958) to guild the constructions of claim (i.e., a statement that advances the position learners take to analyze case with attribution theory), ground (i.e., evidence from case to support claim), or warrant (i.e. logical connections between the grounds and claims that present the theoretical reason why a claim is valid). The *Medium Degree of Scripting* (MD) was implemented through continuous fading-out of the prompts of the external script. The environment handles the fading levels according to a designed sequence with a fixed time interval specified by the researchers in advance. For example, in the end of the tenth phase, learners received only one textbox for creating a whole argumentation (*Scene*) instead of specifying the argument components (*Scriptlets*). Participants in the condition with *Low Degree of Scripting* (LD) received no additional support in solving the problem cases.

As the main data sources, all messages that learners put forward in the text-based communication were divided into units of analysis — syntactically meaningful sentences and subsequently coded on argumentation dimension, which reflects different desired activities to build formally complete arguments . Each segment was coded whether it was a claim, a ground, or a warrant. The SIDE tools (Mayfield & Rosé, 2010) for automatic classification were used for segmentation and coding. The inter-rater reliability was sufficiently high (Cohen's Kappa between human coders and SIDE above .7 (Mu, Stegmann, Mayfield, Rosé, & Fischer, 2012). Content analyses on the argumentation dimension as described above have been applied to the pre-test case to assess the baseline *Initial Internal Scripts* (IS), the *Application of Internal Scripts* (IS) measured the average quality of argumentation as a trio-group on the same dimension but during the collaborative learning process of analyzing three problem cases, as well as the *Development of Internal Scripts* (IS) assessed in the post/transfer case as the one of the indicators of internalized collaboration scripts.

Standard linear regression analysis and a set of two-level Hierarchical Linear Model models with the use of the software HLM 6.08 for windows was performed to analyze the clustered data collected in the present study. Through two dummy codes, namely *Scripting* (LD = 0, MD = 0, HD = 1) and *Fading* (LD = 0, MD = 1, HD = 0) the categorical variables of the experimental treatments can be rendered into quantitative forms.

Results

RQ 1: To what extent does external scripting and fading affect application of IS components during collaborative learning? The regression model using the predictors Scripting and Fading explained about 33% of the variance of the application of internal scripts (R^2 = .33, $F_{(2, 29)}$ = 7.09, p < .01). Both of the predictors had significant positive effects on the application of IS ($\beta_{\text{scripting}}$ = .62, p < .01; β_{fading} = .54, p = .01). Learners supported by scripts, either with high or medium degree did apply more collaboration scripts during online discussion compared with groups in the control condition. We did not find any significant difference between the groups with HD of scripting and MD of scripting (β = .08, p > .50).

RQ 2: To what extent does external scripting and fading affect the development of IS? For each outcome variable, the HLM analyses were performed in four stages. At the first stage, a null model was tested in which no independent variable was included. By adding the group-level intervention variables the second model was to address the effects of various degrees of scripting on learning outcomes.

Table 1 HLM Models: Degree of Scripting Affecting the Development of Internal Scripts

Parameter		Model 1	Model 2	Model 3	Model 4
Fixed effects	Intercept	0.60** (0.10)	0.35** (0.09)	0.34** (0.09)	0.60** (0.14)
Level 1 (Student)	Initial IS.			- 0.04 (0.06)	- 0.16 (0.08)
Level 2 (Group)	Application of IS				0.70* (0.32)
	Scripting		0.57* (0.26)	0.55* (0.24)	0.16 (0.69)
	Fading		0.16 (0.11)	0.15 (0.11)	- 0.18 (0.16)
	Scripting.×Initial.IS			1.47* (0.75)	1.48* (0.73)
	Fading.×Initial.IS			0.07 (0.19)	0.17 (0.18)
Random parameters	σ^2_{u0}	0.17** (0.41)	0.11** (0.33)	0.10** (0.32)	0.04** (0.19)
	σ^2_{e0}	0.47 (0.69)	0.47 (0.69)	0.42 (0.65)	0.42 (0.65)
-2*log likelihood		223.47	217.13	206.24	197.05

Note. Values in parentheses are standard errors. *p < 0.05; **p < 0.01.

As shown in Table 1, the variance of the group level residual errors are estimated as 0.17, which is small but significantly different from zero (χ^2 = 66.23, df = 31, p < .01). By calculating intra-class correlation, 26% of the variances of the development of IS exist at the group level. The regression coefficient for Scripting is significant which means that on average students receiving external scripts with HD contribute 0.57 (p < .05) units of analysis more than students in the control condition. However, no significant difference is found between other treatment groups. The deviances reported here as -2*log likelihood function value reduced from the null model 223.47 to the full model 217.13 with a significant difference (χ^2 = 6.34, df = 2, p < .05), which indicates a better model-fit has been achieved by adding the variable at the group level. Summarily, the empirical finding was against this initial assumption in which fading was expected to foster the internalization of collaboration scripts. Learners with highly structured external scripts produced more formally complete arguments in the transferable post-case than learners in the other two conditions.

RQ 3: To what extent is the positive effect external scripting and fading on the development of IS mediated by the application of IS components during collaborative learning? The last two models are to determine if the application of IS can account for the variation in the slopes after controlling for the effects of various interventions. As shown in the third model, the coefficient associated with the relation between the dummy variable Scripting and development of IS is significant ($\beta_{\text{Scripting}}$ = .55, p < .05). When further controlling the application of IS, it was significantly associated with the corresponding learning outcomes (β = .70, p < .05). The coefficient for the mediated effect dropped down from significant to insignificant $\beta_{\text{Scripting}}$ = .16 (p > .05). The addition of learning process as a predictor yield substantially increased variances which can be explained at the group level, namely from 40% to 70%. The Sobel test indicates that the application of IS mediated the relationship between external scripting and development of IS (p = .01). Meanwhile, the difference between the model deviances (χ^2 = 9.20, df = 1, p < .01) demonstrates a better model fit.

RQ 4: To what extent is the positive effect external scripting and fading on the development of an internal script moderated by the learner's initial internal script? The regression coefficient for the cross-level interaction is 1.47 (p < .05) by multiplying the dummy coding variable Scripting. The significant moderating effect shown that learner with more internal collaboration scripts performed better than learners with less internal collaboration scripts when they were all supported by HD of scripting. MD of scripting did not interplay with internal collaboration scripts (β_{Fading} = .07, p > .05). R^2 with predictors of degree of scripting and initial IS excluding their interaction is close to zero at the individual level; inclusion of the interaction increase R^2 to 0.11. A better model fit was achieved ($\chi^2 = 10.89$, $df = 3$, $p < .05$).

Discussion

The major research questions of this study were to address to what extent does external scripting and fading of an external script affect the application of internal script components during collaborative learning and the development of an internal script (RQ1 & 2). The findings suggested that external scripting and fading facilitate the application of internal scripts during collaborative learning, but the assumed negative effect of external scripts with HD of scripting on the acquisition of IS ('over-scripting') did not occur. In addition the MD of scripting manipulated with fading did not outperform as expected. To bridge the evidence gap in previous studies by addressing the "optimal" degree scripting (*Optimal External Scripting Level Principle*), the current study indicates that an absolute threshold (above which the scripting degree will be 'too much' for all learners) indeed does not exist. Rather, whether an external collaboration script being 'too much' or not, is relative to and depending on the available resource stored in the human mind as internal collaboration scripts (*Internal & External Script Guidance Principles*). This study contributes to the growing empirical literature on the interplay between the internal and external collaboration scripts by addressing to what extent is the positive effect external scripting and fading on the development of an internal script moderated by the learner´s initial internal script (RQ 4). It is surprising that more experiences learner with more internal collaboration scripts benefited most of the full and continuous collaboration scripts, rather than from the fading condition. In the other treatment conditions, namely low and medium degree of scripting, the influence of internal collaboration scripts on argumentation vanished. Therefore, it might be explained that constructing a formally complete argument is challenging for learners due to little 'available' script components in minds, and thus the failure of fading might be due to the removal of external scripts too quickly, which allows the scaffolding residing outside of learner's ZPD and hence led to the unexpected effects. In addition, efforts are paid in the current study to elicit the nature of the relationship between the application and the development of internal collaboration scripts simply differ across external scripting (*Transactivity Principle*) by addressing to what extent is the positive effect external scripting and fading on the development of internal script mediated by the application of script components during collaborative learning (RQ 3). HD of scripting was found to strengthen the configuration/reconfiguration of internal collaboration scripts due to the intensive practices on argumentation provided in the condition with full and continuous instructional supports. The numerous studies on scientific argumentation have suggested that for the overwhelming majority, the appropriate use of valid argument does not come naturally, but rather is acquired through intensive practices (Kuhn, 1991). Thus learner might need more assistance and practice in terms of HD of scripting to complete the challenging task and hence result in internalized collaboration scripts. It can be also explained that the individual learners have been unable to benefit from fading, until experiencing a longer practicing period than the 80 minutes of the collaborative learning phase during which they mastered the relevant aspects of internal scripts. As another drawback of the current study, the learning environment handled the fading procedure according to a predetermined and fixed time-interval which is not truly adaptive to what happens during learning processes. This, thus, is subject to further examination the 'appropriate' rates of fading process that adapts to the learner's real-time performance in future research efforts.

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Multimodal Interactions with Virtual Manipulatives: Supporting Young Children's Math Learning

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Abstract: This study investigates how multimodal interactions impact learning in digital learning environments. More specifically, the study argues that modern virtual manipulatives should offer a rich sensory experience by presenting information visually, aurally, and kinesthetically and that carefully designed perceptual experiences will facilitate learning in young children. To test this hypothesis, sixty (N = 60) second grade students were randomly assigned to learn multiplication using software designed to vary the aural and kinesthetic experience while holding the visual presentation constant. The results reveal that both aural and kinesthetic interactions increased learning outcomes but in different ways and at different points. The paper concludes with a full discussion of the results as well as their theoretical and practical implications.

Introduction

In mathematics, manipulatives are objects used to introduce children to concepts that are difficult to "see" due to their abstract nature and young learners' developmental capacity. Both physical manipulatives, such as beans and blocks, and virtual manipulatives, digital instantiations of such objects, have been shown to help children learn abstract concepts. However, weaknesses in both types of manipulatives have been identified. For example, children often struggle to connect their physical actions with manipulatives to the underlying mathematical concepts. On the other hand, virtual manipulatives designed to help children make such connections, strip-away the benefits of interacting physically with real-world objects. Given this scenario, the following study attempts to improve manipulative learning experiences by combining recent advances in input technologies with well-established multimedia learning principles.

Theoretical Framework

Manipulatives are defined as physical objects specifically designed to foster learning (Zuckerman, Arida, & Resnick, 2005) and studies have shown they can help young children learn abstract math concepts (Sowell, 1989; Suydam & Higgins, 1977; Tooke, Hyatt, Leigh, Snyder, & Borda, 1992). Other studies argue that manipulatives fail to improve student understanding (Rust, 1999; Suydam & Higgins, 1977). For example, Hiebert and Wearne (1992) observed that students performed all the physical steps correctly without understanding the target concept of place value. In another study, Thompson and Thompson (1990) described a similar situation where students failed to link their actions with manipulatives to the underlying mathematical content.

With the advent of technology, physical manipulatives have transformed into virtual manipulatives--interactive visual representations of dynamic objects that present opportunities for constructing mathematical knowledge (Moyer, Bolyard, & Spikell, 2002). Research with virtual manipulatives has found them to be promising educational tools with many advantageous properties (Suh, Moyer, & Heo, 2005). One advantageous property is their ability to help make explicit, through careful design, the connection between the virtual manipulables themselves and the abstract symbols they represent. Yet despite this benefit, virtual manipulatives suffer from a major drawback compared to physical manipulatives: the lack of developmentally appropriate physicality.

Theoretically, virtual manipulatives that takeaway the physicality of real-world manipulatives should result in a more limited sensory experience, which may, in turn, reduce learning potential. However, with today's technological advancements, it may be possible to design a virtual manipulative that offers a sensory experience similar to traditional physical manipulatives while preserving the pedagogical advantages of digital learning environments. The current study explores this idea by examining how a multi-modal virtual manipulative that can be experienced visually, aurally, and kinesthetically, impacts young children's understanding of multiplication.

Method

Research Design and Participants

To investigate the impact of a multimodal virtual manipulative on student learning, the researchers developed a computer-based virtual manipulative designed to introduce the concept of multiplication to children through repetitive addition (details below). Using this research software, a 2 x 2 factorial experiment with two independent variables was designed, resulting in four experimental groups. The two independent variables were audio narration (present vs. not present) and input device (touchscreen vs. computer mouse). Students in all four experimental groups received visual information that contained mathematical notation relevant to their interactions with the on-screen graphical manipulatives. In addition to the visual math notation, some students received audio narration (A) corresponding to the visual math notation, and others received no audio narration (NA). Moreover, some students controlled the virtual manipulatives using their finger on a touchscreen device (T), while other students used a computer mouse (M). Table 1 shows the four experimental groups. Sixty (N = 60, Female = 22, Male = 38) second grade students from New York City public schools were randomly assigned to four groups.

Table 1: 2 x 2 Factorial Experimental Groups and 2 x 1 Control Groups

Experimental Groups		Input Device	
		Fingers on Touchscreen (T)	Computer Mouse (M)
Audio Narr.	Presence (**A**uditory)	A-T (N = 15)	A-M (N = 14)
	Absence (**N**o Auditory)	NA-T (N = 15)	NA-M (N = 16)

Prior to using the software for the first time, all students took a pre-test to measure their prior knowledge and understanding of multiplication. Students with a score of more than fifty-percent were deemed too proficient in multiplication and were subsequently dropped from study. There were no significant differences between groups as measured by mean pre-test score.

After the pre-test, students used the virtual manipulative software for five sessions and took a paper-based mid-test. Students then used the virtual manipulative for five more sessions and took a paper-based post-test. The tests consisted of 33 fill-in-the-blank and matching questions, with a maximum score of 34. The format of the pre-, mid-, and post-tests was identical, however, the 33 items, and the order in which they were presented varied slightly from version to version. In total, the virtual manipulative software was used for ten sessions over six weeks. Each session lasted an average of twenty minutes and each participant completed a pre-test, mid-test, and post-test.

Research Instrument

The virtual manipulative software built for this study is called *Puzzle Blocks*. The goal of *Puzzle Blocks* is to build common shapes such as a house or a car by moving small groups of blocks repeatedly to form bigger groups of blocks. For example, if students need a group of six blocks, they build it by adding a group of two blocks three times (2+2+2=6). While moving the on-screen blocks, students receive visual feedback that is both graphical (the blocks) and textual (mathematical notation). In addition to visual feedback, the software provides auditory narration temporally aligned with the visual mathematical notation. For example, when students grab a group of two, they see the visual notation of "2" and hear an audio voiceover say, "two." Similarly, when students move the group of two blocks, visual notation of "x1," "x2," and "x3" appears, and the corresponding audio narration reads aloud, "times one," "times two", and "times three", as the blocks are dropped into place. When a larger group of blocks is complete, the full mathematical equation (i.e., "2 x 3 = 6") appears and the audio voiceover reads, "two times three equals six." The goal of this design is to help students make the connection between the graphical blocks, their actions with them, and the underlying mathematical concepts of grouping, repetitive addition, and multiplication. Importantly, the presence of the audio narration can be turned on or off by the researchers in order to form the audio narration group (A) and the non-audio narration group (NA).

Figure 1. Moving a group of two blocks three times, completes the group and the full equation is diplayed

Puzzle Blocks is also designed to vary the kinesthetic interaction experienced while manipulating the on-screen blocks. This was accomplished by deploying the software on laptops and tablets. On the laptop platform, students used a traditional computer mouse (M) to manipulate the on-screen blocks. On the tablet platform, students used their finger on a touchscreen (T), to manipulate the virtual objects. The authors argue that the two input methods result in different kinesthetic experiences that might impact student learning.

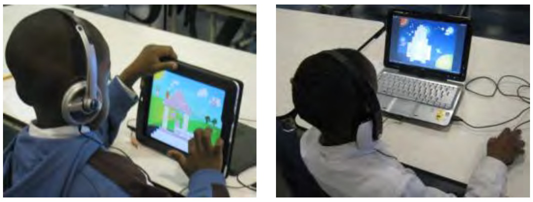

Figure 2. Using *Puzzle Blocks* with either a finger on a screen or a computer mouse

Data Analysis

To measure students' learning outcomes, pre-, mid- and post-tests scores were analyzed using a Profile Analysis. Learning outcomes between the pre-test and mid-test, the pre-test and post-test, and the mid-test and post-test were compared between all four experimental groups. The impact of the two factors, the absence or presence of audio narration (A vs. NA), and the two input devices (M vs. T), were also examined.

Results

Learning Outcomes

The mean scores of participants' learning outcomes from pre-test to mid-test, and pre-test to post-test, and mid-test to post-test for each group are presented in Table 2.

Table 2: Learning Outcomes by Group

Group	Pre- to Mid-Tests		Pre- to Post-Test		Pre- to Post-Test	
	M	SD	M	SD	M	SD
A-T (N = 15)	20.700 (61%)	8.261	28.067 (83%)	6.543	7.367 (22%)	7.965
A-M (N = 14)	19.893 (59%)	6.625	23.464 (69%)	6.843	3.571 (11%)	4.437
NA-T (N = 15)	15.567 (46%)	7.766	21.767 (64%)	7.805	6.200 (18%)	6.716
NA-M (N =16)	14.563 (43%)	8.828	18.125 (53%)	9.141	3.563 (10%)	5.961

On the mid-test, there was a marginally significant difference among the groups' scores, F (3, 56) = 2.474, p = .071. The A-T group had the highest mean score increase from pre-test to mid-test (M = 20.700, SD = 8.261) and the NA-M group had the lowest mean increase (M = 14.563, SD = 8.828). From the pre-test to the post-test, the A-T group had the highest mean score increase (M = 28.067, SD = 6.543) and the NA-M group showed the lowest mean score increase (M = 18.125, SD = 9.141). Differences between the groups' score increases from pre- test to post-test were significant, F (3, 56) = 5.025, p = .004. Lastly, the groups' score increases from mid-test to post-test were examined. The results show the differences from mid-test to post-test for each group were not statistically significant, F (3, 56) = 1.338, p = .271.

Main Impact of the Auditory and Kinesthetic Modalities

When the main impact of the two factors on students' learning outcomes was examined, the results reveal that the presence of audio narration led to significantly higher learning outcomes on the mid-test, F (1, 56) = 6.941, p = .011, and significantly higher learning outcomes on the post-test, F (1, 56) = 9.272, p = .004, compared to no audio narration. However, the presence of audio narration was not a significant factor between the mid-test and post-test, F (1, 56) = .125, p = .725. On the other hand, the kinesthetic modality was not a significant factor on students' learning outcomes between pre-test and mid-tests, F (1, 56) = .363, p = .549. However, it was significant factor between pre-test to post-test, F (1, 56) = 5.284, p = .025. Finally, it was marginally significant on students' learning outcomes between mid- to post-tests, F (1, 56) = 3.756, p = .058.

Conclusion

The purpose of this study was to systematically test the design of a modern virtual manipulative environment that provides young learners with visual, aural, and kinesthetic interactions related to a math concept and how such multimodal interactions might impact learning. The results show that the type of multimodal interaction afforded by the virtual manipulative environment impacted learning outcomes as measured by paper-based tests. Participants' aural and kinesthetic experience seemed to influence what was learned. However, the impact of the aural and kinesthetic experience seemed to influence learning in different ways and at different points in the ten-session experiment.

After five sessions (mid-test) with the virtual manipulative environment, the presence of audio narration was a significant factor that helped students learn the concept of multiplication. Furthermore, after ten sessions (post-test), the presence of audio narration remained a significant predictor of learning. The kinesthetic experience also impacted student learning, but in different ways. After ten sessions (post-test) controlling the virtual manipulatives with a touchscreen resulted in significantly higher learning outcomes compared to controlling the manipulatives with a computer mouse. This was not the case after five sessions with the software.

Discussion and Scholarly Significance

From a theoretical perspective, the findings support the notion that rich perceptual experiences may promote perceptually-rich mental simulations, which in turn, may lead to better student learning and understanding (Black, Segal, Vitale, & Fadjo, 2011). However, more research is needed to understand what constitutes a rich perceptual experience in a digital environment. There is much to learn in terms of how such experiences should be implemented in order to optimize learning without overwhelming human cognitive resources. In terms of this study, finding that varied kinesthetic experience seems to influence student learning is especially intriguing given the traction of embodied cognition theories and the emergence of innovative perceptual and tangible user interfaces.

In conclusion, this study illustrates the potential of technology to augment, enhance or build-upon traditional instructional interventions in the domain of math. Although further research is needed to confirm the study's findings, and the limited sample size limits their generalizability, the work presented here should encourage educators, game designers, and researchers to extend their understanding of the role multimodal interaction in learning.

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Individual and Collaborative Reflection at Work: Support for Workplace Learning in Healthcare

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Abstract: One approach to integrate CSCL in the workplace is the support of collaboratively reflecting on work, aiming at developing and evaluating tools that support reflection at the workplace. As an example, we describe the "Talk Reflection App" and its evaluation. On a conceptual level we show the relevance of articulation, shared artifacts, and the strong interrelation between individual and collaborative activities. On the empirical level we give examples of learning outcomes.

Introduction: Learning at the Workplace by Collaborative Reflection

A large part of (life long) learning happens informally at the workplace. *Reflecting* on one's own or on others' behavior is a typical mechanism of learning at the workplace (e.g., Boud, Keogh, & Walker, 1985). In this paper, using the case of reflection in a hospital ward, we present an analysis of and socio-technical solution for (collaborative) reflection and learning.

The example of the "Talk Reflection App" for collaborative reflection in hospitals demonstrates how methods and concepts of CSCL can be successfully transferred to workplaces.

In its essence, reflection helps to transform daily work experience into learning (Boud et al., 1985; Daudelin, 1996; Knipfer, Wessel, & Cress, 2013). Through reflection, people step back from an experience and explore it in order to come to new insights. Reflection can be initiated when some change or problem requires work practices to be adjusted. It involves a re-evaluation of the situation with a focus on the situation and affective reactions to it. Reflection is not just individual but has multiple levels: Actors of reflection can be individuals, teams or organizations. Individuals can reflect about own experiences and about experiences made in a team or an organization. Likewise, groups can reflect on individual or group behavior. The processes of *collaborative reflection* can be well described with models about collaborative learning (Cress & Kimmerle, 2008; Herrmann, 2003; Stahl, 2006), which intertwine individual information processing and re-evaluation of understanding with shared understanding and negotiation of meaning in groups. By a process of inference and abstraction, new insights, learning outcomes and changes in behavior can emerge on individual and group levels (Kimmerle, Cress, & Held, 2010; Knipfer et al., 2013).

Technical support for reflective learning has only been explored intensively in the context of education. A major aspect of this work is support for the externalization of experiences by structured communication (Baker & Lund, 1997), note-taking (Kim & Lee, 2002), drawing visualizations (Lin, Hmelo, Kinzer, & Secules, 1999) or tracking one's own learning history (Scott, 2010). This shows that for collaborative reflection experiences need to be articulated (Bannon & Schmidt, 1992), shared with others, and that other people need to refer to them. However, in the context of *learning at work*, which happens mainly informally (Eraut, 2004) and cannot rely on upfront preparation (Prilla, Herrmann, & Degeling, 2013), such support has not been widely researched. Besides support for specific situations like project debriefings (e.g., Boud et al., 1985), research mainly proposes tools such as learning journals and portfolios to externalize experiences (e.g., Scott, 2010). In a current project (http://www.mirror-project.eu/) tools are developed to collect and reflect on information about work experiences in several formats, including input on specific experiences in a diary format and ratings on mood during an experience. This information can then be shared and used by its authors and other as a "mirror" to reflect upon own or others' work experiences. Prior studies show that supporting tools should address four different kinds of *articulation*, forming a *reflection cycle* (Prilla, Degeling, & Herrmann, 2012)*:* the externalization of experiences, of individual and collaborative reflection, and of outcomes of reflection (Figure 1).

Case Study: Support for Reflection in a Hospital with the "Talk Reflection App"

To explore reflection in in the field, we conducted a series of studies in different workplaces (Prilla et al., 2013). One was a hospital, where we worked with the staff of a ward caring for patients suffering from acute strokes and other neurological emergencies. Our work included interviews and observations on reflection and its role in daily work. It revealed that although there is a strong need for reflection, there is only little support for capturing experiences (e.g. quick notes), systematically revisiting them and following up on them afterwards (Prilla et al., 2012). In many situations, ideas for solutions were lost after reflection and it was difficult and time-consuming to remember experiences. In these cases, learning opportunities were lost. Based on these observations we developed a technical pilot, the "Talk Reflection App", to support medical staff in reflecting their conversations with relatives (Prilla et al., 2012). This topic was chosen because physicians stated repeatedly that although they felt a need to more systematically about think them (as they often had to convey bad news to relatives while keeping calm and acting professionally) their education did not prepare them for such situations and they therefore often sought help from other colleagues.

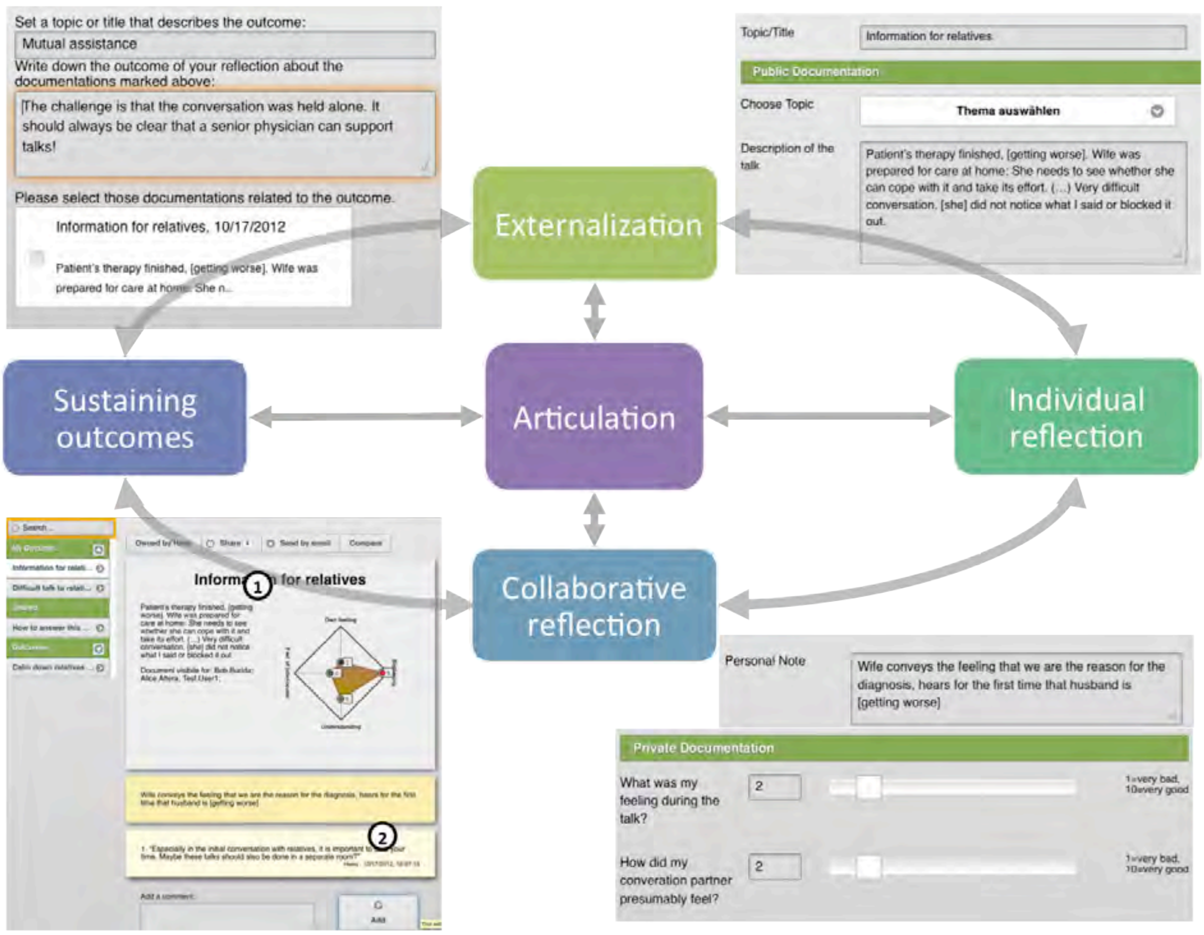

Figure 1: Tool support for articulation: Screen shots of the Talk Reflection App

The Talk Reflection App supports all forms of articulation mentioned above. First of all, medical staff can document problematic *experiences* ("public documentation", Figure 1, upper right corner). As this generates further effort for staff, this documentation was also used to replace the (mandatory) documentation of conversations with relatives in the hospital information system. To stimulate *individual reflection*, the tool asks the user to add own thoughts about the situation by answering questions such as how they felt during it and how worried they are about the situation ("private documentation", lower right). This externalization leads to thinking about the situation and considering why the experience was negative. A user can share this documentation (Figure 1, no.1) with others, who may document their own interpretations or experiences with similar issues (Figure 2, no. 2). This triggers *individual* and *collaborative* reflection among colleagues with similar experiences. Through the combination of own attributions to the situation and others' experiences, ideas or comments, the group can come to a new understanding of a situation and how to deal with it in future work. To preserve these *outcomes*, the app contains a section to document outcomes of reflection (Figure 1, upper left).

Reflection Support Applied: Observations of Talk Reflection App Use

The Talk Reflection App was used by five physicians in a four-week trial at the hospital. During this time, we conducted two reflection meetings to observe how the content in the app was used to reflect. Before the first meeting, adoption was low, but after this meeting, in which the notes of one physician were successfully used for reflection, the physicians started to use the app more intensively. In the 12 days between this meeting and the meeting closing the trial period, they documented seven conversations, made seven comments (some documentations had no comments) and wrote down four outcomes of reflection – all outcomes were documented during the final reflection meeting. Given that problematic conversations do not occur every day and that using the tool was new to the physicians, we consider the amount of documented conversations and outcomes as sufficient for the short period, although we had expected more comments annotating one's own and others' content.

Table 1: Example for reflection among physicians (translated from German by the authors)

Phase	Contents
Externalization of experiences	"Patient's therapy finished, [getting worse]. Wife was prepared for care at home: She needs to see whether she can cope with it and take its effort. (…) Very difficult conversation, [she] did not notice what I said or blocked it out."
Own comment (individual reflection)	"Wife gives me the feeling that we are the reason for the diagnosis, hears for the first time that husband is [getting worse]"
Comment of colleague (collaborative reflection)	"Especially in the initial conversation with relatives, it is important to take your time. Maybe these talks should also be done in a separate room?"
Discussion in group reflection meeting	Physicians remembered similar situations and stated that they are often also affected when they have to convey bad news. The reporting physician was also asked whether she had thought of asking a senior physician to help her.
Joint outcome	"The challenge is that the conversation was held alone. It should always be clear that a senior physician can support talks!"

Table 1 shows an example of how the app was used to reflect. A physician documented an emotionally challenging situation of a communication with a patient's wife. Her *own comments* show that she was emotionally affected, including a first idea for a reason (the wife had not been told about the state of her husband before). A *comment of a colleague* proposed to use a more appropriate room as a solution based on his experiences from own conversation. This indicates that the problem was not only be caused by the severity of the diagnosis, but also by the way the conversation was carried out. In the *group reflection* during a meeting, other physicians reported similar experiences and proposed that a senior could have been asked to join the critical conversation. They agreed on this proposal and documented it as a joint outcome. This shows how documentation of an individual experience turned into a change of team routines and how it affected individual practice as well as the whole team.

In this and other examples, the physicians were able to reconstruct their experiences in later situations, using the documentation as a memory aid. In meetings, verbal reports and additions to the content in the app triggered collaborative reflection, although the physicians had been reluctant to use the commenting feature in the app before the meeting. Afterwards, they stated that they found it valuable if others commented on their documentation, but that they had not known what to comment on others' documentation. Furthermore they liked the opportunity to write down reflection outcomes, but had to be reminded to do so during meetings – outside meetings, they did not document any outcome. This shows a gap between the value the physicians generally attributed to the features of articulation support and their usage. Obviously, guidance is needed within the app to use these features. Further work will address this need, the enhanced integration of the app into work practice, and user activation.

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A Multi-Level Analysis of Engagement and Achievement: Badges and Wikifolios in an Online Course

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Abstract: Multiple levels of data from an asynchronous online course were analyzed to explore student engagement and achievement around a particular course concept. This study examined how productive disciplinary engagement around "wikifolios" via threaded commenting on those wikifolios fostered learning that transferred to performance on external achievement measures not directly targeted in the course. The findings show that a new course feature, peer awarded badges, were effective markers of productive disciplinary engagement, and impressive achievement gains were accomplished without resorting to dreary expository instruction that typifies the majority of online learning. Implications for the design of productive online learning and further areas for research are discussed.

This paper describes a multi-level analysis of learning outcomes using data from one cycle of ongoing design based research of a fully online graduate-level education course. This course and the underlying design principles foster diverse learning outcomes by aligning activity across three increasingly formal levels: (1) *productive disciplinary engagement* (PDE; Engle & Conant, 2002) in drafting and discussing weekly *wikifolios*, (2) enduring individual understanding of targeted course concepts in those wikifolios, and (3) aggregated achievement on multiple-choice items drawn from the publisher's item pool for the textbook.

Asynchronous online learning is unique in that it allows instructors and students time to process exchanges and formulate meaningful posts, allowing for thoughtful responses and deep processing of concepts (Swan, 2002). The existence of online artifacts and persistent threads of discourse around those artifacts creates an opportunity for rich analysis of the trends in computer mediated discourse (Rovai, 2002). A previous analysis of a prior iteration of the course examined individual understanding and aggregated achievement (Hickey & Rehak, 2013). This present analysis traces the learning of a particular course concept, teaching & learning mathematics, across all three levels (PDE, enduring understanding, and aggregated achievement). The following questions were addressed: (1) to what extent did students engage with this concept? (2) Did a new course feature (peer awarded badges) accurately flag PDE? (3) Did student engagement foster enduring understanding of teaching & learning mathematics? (4) Did this course design positively impact aggregated achievement on measures that were independent of the way the content was taught?

Research Context

Since wikis were invented in 1995, they have transformed the way we catalog, construct, share, and refine information. However, the potential uses of wikis in education have been somewhat overshadowed by debates surrounding the accuracy of information found on collaborative encyclopedias (e.g. Crovitz & Smoot, 2009). This course uses wikis as a type of alternative to e-portfolios; thus, they are called "wikifolios" (Hickey & Soylu, 2012). However, both the wikis and the threaded comments in which students discussed the course concepts are remarkably simple. This made the wikifolios ideal for everyday class use and allowed the students and course refinements to focus deeply and directly on engagement and learning.

Much research in Computer Supported Collaborative Learning (CSCL) focuses on analysis of individual and shared knowledge building using some type of collaborative communication technology (e.g. Cress & Kimmerle, 2008; Greenhow & Belbas, 2007; Moss & Beatty, 2006). It has been argued that the differences in theoretical and methodological perspectives in this body of research can be reconciled by careful positioning of results (Clara & Mauri, 2010). In an effort to explicate the positioning of this particular study, it is necessary to delve into the constituent context of the environment, regarding context not as a variable external to the course but, as Cole (1996) discusses, *context as that which intertwines*.

Instead of going beyond the individual actions and mind (as suggested by Arnsenth & Ludvigsen, 2006), this analytical approach employs a situative theory of learning (Greeno et al., 1998) that examines the aggregated engagement of the class and how the affordances of the context are taken up by the students. Overall performance on distal achievement items (assessment items that are not directly aligned to the curriculum activities) is used to make arguments regarding validity of the course design in the seemingly inevitable broader context of increased accountability.

In light of the surging expectations for educational accountability, assessment and evaluation of e-learning has taken on new significance (Harmon & Lambrinos, 2008). In response, instructors, schools, and researchers are exploring various strategies to ensure security of online tests and document the validity of scores (Jung & Yeom, 2009; Rowe, 2004). A melding of these concerns with situative approaches to assessment and learning, along with design based research methodology, has resulted in a set of core design principles that are currently called *Participatory Assessment* (Hickey & Rehak, 2013).

The data for this study comes from the online archive of an asynchronous graduate course, *Learning & Cognition in Education*. In this particular semester fourteen School of Education students were enrolled. The instructor had been teaching the course in its current format since the fall of 2008, making use of a Sakai course management platform, OnCourse. OnCourse has a wiki feature that allowed the students to post their weekly wikifolios locally. Each student had her own wikifolio where all of her artifacts were displayed and discussed. Reflecting one of the core design principles and Engle & Conant's (2001) suggestions for problematizing disciplinary content, every wikifolio had students articulate the three *most relevant* and one *least relevant implications for education* found at the end of each chapter of a disciplinary text, as they related to each student's self-defined instructional goal and setting. In the last five weeks of the course, subgroups of students created collaborative group wikifolios around the chapters on literacy, comprehension, writing, mathematics, and science. Reflecting another core design principle, the wikifolios and student comments were never directly graded. Instead, students only needed to post three coherent reflections on their engagement and collaboration to receive full points for the wiki posting, which made up the majority of their course grade. The grading mechanisms for the course have been explored in a prior paper (Hickey & Rehak, 2013) and are beyond the scope of the current analysis.

Design-based refinements had been made across four prior semesters. Many of these refinements focused on increasing the amount and meaningfulness of interactive engagement via threaded comments posted directly on individual wikifolios. One new feature, peer awarded "badges," were integrated into students' weekly assignments. Quite simply, badges were comments that included the distinctive string "$$$" to highlight a classmate's particularly productive contribution. Figure 1 shows a typical badge in context.

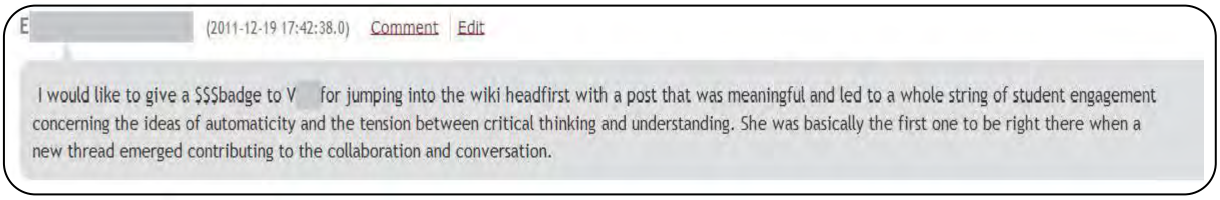

Figure 1. Typical Peer Awarded Badge

Synergy between the design of this feature and the design of the research were obtained by framing both using Engle and Conant's (2002) notion of PDE. More specifically, the assignment prompt included an explanation of the types of engagement that were productive and disciplinary, and students were asked to award badges to contributions that exemplified PDE. It was articulated that a valid badge needed to explain why the engagement was productive and disciplinary. As described below, the content of the badges and interactive context was then analyzed to determine the extent to which the feature actually represented PDE.

Resulting Engagement

Overall student engagement in the course was high. The ten individual weekly wikifolio posts averaged 1,569 words with an average of 120 comments per week, or 9 comments per individual wikifolio. The comments were an average length of 95 words per comments. Of these comments, just 16% were standalone comments that were not part of a threaded discussion. The five collaborative group wikifolios averaged 3,473 words, with an average of 40 comments that were a length of 92 words, and just 8% of comments were non-threaded. The mathematics group wikifolio was collaboratively composed by three students; it was the longest group wikifolio at 4,630 words and had 50 comments.

Out of the 50 comments on the mathematics group wikifolio, 8 of the comments were peer-awarded badges. Both the badge awarder's rationale for awarding and the context that resulted in a badge were a priori coded using the construct of PDE. Rationale and context were considered to represent PDE if they were both disciplinary (concerning the field of teaching and learning) and productive (intelligently moved the conversation forward). Two coders had 100 percent agreement that 2 of the 8 badges did not sufficiently warrant how the engagement, to which they were awarding a badge, was productive or disciplinary. Figure 1 (above) shows one of the two badges that lacked PDE in the awarding rationale. Encouragingly, all 8 of the badged interactions were determined (with 100 percent agreement) to be both productive and disciplinary. While the awarder of the badge may have failed to continue the disciplinary conversation, all badges did recognize engagement that was both disciplinary and productive.

Content Analysis

Ongoing qualitative content analysis based on the concept of community "uptake acts" (Suthers, 2006) of course ideas (referred to as text) is revealing how this online context fosters discourse that should leave behind enduring individual understanding of course concepts and aggregated achievement that should convince skeptics of the value of this approach. Examining uptake reveals how the learners take up the abstract course concepts within the context of teaching & learning mathematics and other related domains. Table 1 displays the analysis of an illustrative thread that was typical of the exchanges in the mathematics group wikifolio.

Table 1. Content analysis of a thread. (emphasis added)

Student (timestamp)	Content of post	Analysis
Mariah (2011-12-02 17:09:42.0)	I really appreciated your relevant debate. **In reading this chapter, I kept thinking, "I wish I had been taught like this!"** I enjoyed solving equations because they're so black-and-white - and I excelled at them - but I've never learned how to use them beyond the classroom, even in my college level honors calculus course. **While practicing skills gives students a solid foundation, without some connection to real life, the skills are meaningless. I really wish I had been taught why these skills were important**. I feel like I'd be a lot smarter if that had been the case. I think your tenth and fifteenth relevant specifics tie into this debate for me.	Uptake of text by comparison to personal experience Uptake of text by comparison to personal experience
Eric (2011-12-02 18:32:10.0) -in response to Mariah	I think that the "why" component of teaching is the most power, one for the reason you mention about connections to real life. **Two, because we can't always remember the exact formulas for everything we've ever learned, but if we understand why things are the way they are, then we can reconstruct those "formulas" or "algorithms"** for ourselves in the real world to a close enough approximation to get by with whatever task we are trying to accomplish. To relate this to the learning goal: we might not remember every single rule that governs a median average, but if we understand the basic idea and the "why" of a median average, we are going to figure out a number that is close enough to the median average to satisfy the need we have in the real world.	Uptake of text by connecting current context to a previous chapter of the text
Courtney (2011-12-03 21:51:13.0) -in response to Eric	I think it also has a lot to do with students just really being curious as to how to store the information. When we are teaching them about money, they know they are going to how to use it in every day situations even to buy a pop. But when we are teaching them about these central measures of tendency they are most likely giving you that deer in the headlights look and trying not to fall asleep**. If you find something for them to tie it to they are not only going to grasp on more but already remember it better.**	Uptake of text by connecting peers' comments on the concept

This analysis suggests that all three of these students made meaning of the abstract concepts from the text by discussing them in a knowledgeable manner and built on the ideas their peers were expressing.

Another advantage of this new feature that was not explored concerned the badges' value for helping the instructor prioritize which of the numerous comments and exchanges to focus on. Specifically, once wikifolio drafts and comments were posted, the instructor would search for the distinctive string and begin contributing comments around the badged interactions.

Resulting Understanding and Achievement

Impact on individual understanding was assessed with timed (5 minutes/item) open-ended items that asked students to consider the relevance of the various chapter implications as they related to the design of the actual course. The majority of the students received full points on the majority of the items. Impact on aggregated achievement was measured using time limited tests (60 seconds/item) consisting of selected-response items randomly chosen from the subset of items in the textbook item bank whose answers could not be readily located in the textbook. The pretest was required but ungraded, and consisted of 25 items. The midterm and final consisted of 20 and 30 items that combined covered the same concepts as the pretest; these exams were graded but comprised only a small percentage of the overall course grade. A one-way ANOVA showed student engagement led to significant gains in the posttest analysis. The increase in average percentage correct on the midterm (83.82%, SD = .1189) and final (80.24%, SD = .1073) compared to the pre-test (66.23%, SD = .1189) were both statistically significant [$F (1, 26) = 10.03$, $p = .004$, and $F (1, 26) = 10.70$, $p = .003$] with respective effect sizes of $d = 1.036$ and $d = 1.060$.

Of specific interest is the gain on the item concerning a very specific mathematics concept. The question was, "CHANGE-ADD-TO and EQUALIZE are examples of?" On the pretest, only 14% of students correctly answered the question, while on the final 100% of students correctly answered the question. This change is striking in that the students were never informed of their score or the correct answers to the pretest questions. Also this concept was never directly discussed in the group wikifolio or any of the comments on the wikifolio. Rather, it suggests that the students' personally relevant contexts did indeed provide students a means to engage with the text in meaningful ways. Additional analyses currently underway are examining other examples of this link between PDE and aggregated achievement.

Conclusions

Overall student engagement in the course and in the mathematics group wikifolio was high, and most comments were substantive in that the content of the comments built on the concepts of the text and ideas of peers. The new course feature, peer-awarded badges, appeared to recognize PDE. Because recognizing desired forms of engagement is usually necessary for promoting it, this seems like a useful direction for this research. This study compelled the addition of a new design principle to the set of core design principles employed. This new design principle necessitates exploration in future iterations of the course. A comparative study using content analysis to explore the differences in commenting with and without badges could help determine whether the badges encourage PDE or if they are simply good markers of PDE. Aggregated student achievement was satisfactory, suggesting that this course design fosters more than student engagement, but also a useful learning experience.

As online learning continues to grow more innovation and research is needed to ensure students are indeed learning in these courses. These results suggest that avoiding the discussion of concepts in the abstract and allowing students to choose their own personally meaningful context for engaging with the text can lead to efficient online interactions, despite the many barriers of online learning. Peer-awarded badges in this course were much more than "gold stars" and may offer a means of fostering meaningful engagement with typically abstract course concepts.

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Learning to Facilitate (Online) Meetings

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Abstract: We describe an approach to teaching collaboration skills directly by building on competences for meeting facilitation. (Online) meetings provide a rich arena to practice collaboration since they can serve multiple purposes: learning, problem solving, decision making, idea generation and advancement, etc.. We argue that facilitating meetings is a competence worth developing in students and describe the main knowledge and skill components that pertain to this competence. We then describe some implemented software tools that can be used in schools and colleges to provide opportunities for practicing and developing group facilitation skills.

The Challenge of Teaching Collaboration

The focus in CSCL is naturally on group learning: the group comes together with the main purpose to learn about something. This is different from collaboration outside of educational settings, where the main purpose of collaboration and cooperation is not only learning (building capacity), but also (and more frequently) problem solving, decision making, deliberating issues of shared concern, engaging in a change process, etc (Romano & Nunamaker, 2001). The purpose of real world collaboration is as often to organize for action and to create commitment to a course of action than it is to distribute information and get agreement on terms (share information, build community). Another purpose is to advance the thinking, which can be seen as similar to the goals of knowledge building (Hakkarainen, 2009). However, even then in real world settings other than academic ones, the advancement of thinking is often embedded in a more action-oriented endeavor, such as creating new products, services, or processes.

While there are many good reasons for separating collaboration for learning from other purposes, this can lead to a restriction of opportunities to practice these other forms of collaboration, which are not only important for business purposes, but also for civic action. The situation is not quite as bleak since educational collaboration will often include problem solving and decision making etc., but it is worth keeping in mind that collaboration for the (sole) purpose of learning is comparatively rare in non-educational settings; there, people meet and collaborate to get things done.

Our general suggestion is to extend the forms of collaboration considered in CSCL beyond those focusing primarily on learning, so as to develop in students in secondary and tertiary education a broader set of collaboration competences. This extends the argument made by Hakkarainen and others with respect to idea advancement. Our specific proposal is to exploit the richness that *meetings*, both face-to-face and on-line, offer for learning. We follow Romano and Nunamaker's definition of a meeting: "a focused interaction of cognitive attention, planned or chance, where people agree to come together for a common purpose, whether at the same time and the same place, or at different times in different places" (2001, p. 1) But just participating in meetings will not be sufficient for learning about group and communication processes, develop skills for productive collaboration, and develop attitudes and values that are conducive for productive team work. Therefore, our approach includes teaching students how to *facilitate* meetings, how to help a group to do its best thinking. The meeting format we focus on is that of synchronous meetings, both with co-location of participants ("face to face") and without (e.g., chat based, and/or some form of audio/video conferencing).

Space is too short to provide a comprehensive research overview. Suffice to say here that the work from CSCL closest to ours is the one on knowledge building already mentioned, and on supporting synchronous argumentation (Asterhan & Schwarz, 2010; B. B. Schwarz & Asterhan, 2011). We will present more of the literature in the Discussion section, after having introduced our own approach.

Learning to Facilitate Group Meetings

In order to identify the competences that are required to facilitate meetings, we are guided by the literature on professional meeting facilitation. A facilitator is one "…who contributes structure and process to interactions so groups are able to function effectively and make high-quality decisions. A helper and enabler whose goal is to support others as they pursue their objectives" (Bens, 2012, p. viii). While a meeting facilitator (also called meeting moderator) refers usually to somebody professionally trained (Schuman, 2005; R. Schwarz, 2002), we use the term here as a *role* a group member takes on for a limited time (one or more group meetings) to help the group in specific ways to do its best thinking. While a facilitator's activities are to some extent always contingent on how a meeting develops, there are numerous ways in which the facilitator can prepare meetings, anticipate meeting process and outcomes, and document process and outcomes. It is in particular these preparatory steps that make facilitation a teachable skill set in the context of schools and colleges, whereas the larger skill set required for proficient facilitation—including strategies to cope with difficult group dynamics—need to be developed through systematic professional education and ample practice. The activities that a student in the facilitating role can prepare and help to enact comprise agenda planning, meeting activities planning, keeping group memory, facilitating decision making, and documenting meeting outcomes. The literature on how to realize these types of activities and what artifacts are involved is extensive (e.g., Justice & Jamieson, 2006; Kaner, 2007). The skills that we think can realistically be developed on the middle school level, for instance, are depicted in Table 1.

Table 1: Meeting facilitation skills.

1. Preparing a meeting: 1.1 The group's agenda 1.2 The facilitators meeting process plan 2. Conducting a meeting: 2.1 Guiding the group through the process 2.2 Keeping group memory (note taking, visualizing)	3. Documenting meeting outcomes: 3.1 Preparing meeting minutes for group use 3.2 Communicating the meeting outcomes beyond the group 4. Reflecting and learning: 4.1 Soliciting feedback on one's facilitation work 4.2 Formulating insights and future learning goals regarding group facilitation

Towards Computational Support for Practicing (and Assessing) e-Facilitation Skills

We have in the Next-Tell project (www.next-tell.eu) developed computational support that can be used in classrooms to provide opportunities to practice meeting facilitation, and to help the teacher provide guidance and feedback. The guiding scenario is one where the class is engaged in some kind of group-based project work that extends over a couple of weeks; for instance, a longer lasting inquiry process in science that culminates in a presentation of findings. We assume that students have (e.g., weekly) face-to-face meetings (with at least one laptop per group), and/or online meetings, using Skype or some such as the web-conferencing tool. A group is formed of 5-7 students, by the teacher. The teacher also has created a schedule that specifies who will be in the facilitator role for each meeting. Our technical solution supports in particular the student in the facilitator role.

Planning a meeting

A week or so before student F has to facilitate a meeting, she is required to engage in the meeting planning, and discuss her plan with the teacher. F uses a meeting planning tool that allows her to select from a pool of meeting activities (called *meetlets*, Fig. 1A) and arrange these in a sequence (Fig. 1B). The planner allows also to express parallel activities, for breaking the group into subgroups, e.g., pairs. Any meeting plan can be stored at any time, and accessed from a library of plans (Fig. 1C), thus also allowing re-use of plans and plan components. Both student and teacher can access the tool and the library via a web browser.

Each node in the meeting plan (Fig. 1B) can be expanded, offering the user then a set of attributes that can be further set or changed from their default values. Since each node, i.e., meetlet, represents an activity, the attributes refer to parameters of the activity. For instance, for a meetlet describing a brainstorming activity the student could further specify details of this activity. An important set of parameters describes which artifacts the activity overall (or each sub-step in the activity) needs and/or generates. For instance, for a brainstorming exercise the student may set up a Google document for each group member plus one to bring the ideas together, and specify the links to these documents in the plan. Both the student and the teacher can step through the (partial) plan at any time to see how the activity (sequence) will look like to the group ("activity stepper"). The meeting agenda that the participants get is a substantially reduced subset of the information in the facilitation plan.

Running and documenting a meeting

Depending on the circumstances when the meeting is conducted, F can decide to print out all documents needed for the meeting in advance, or in case all team members have access to a computer or tablet device, can present the documents needed for the activities online. In the case where the technology is available, F can use the Activity Stepper, a piece of software that interprets the plan and presents the activities step by step, under the control of F. This makes it easier to conduct and document the meeting (no paper handling), but requires that each group member has access. The online meeting resources are essentially made up of Google Apps, with a particular use of Google Spreadsheets, but also Docs, Presentations, and Drawings. In addition to gathering these artifacts, which reflect the meeting activities, F is requested to solicit towards the end of the meeting feedback from the group members, and to write a reflective piece, all of which is then shared with the teacher (either through Google Folders, and/or through an e-portfolio that we provide in addition, but that is not further described here.)

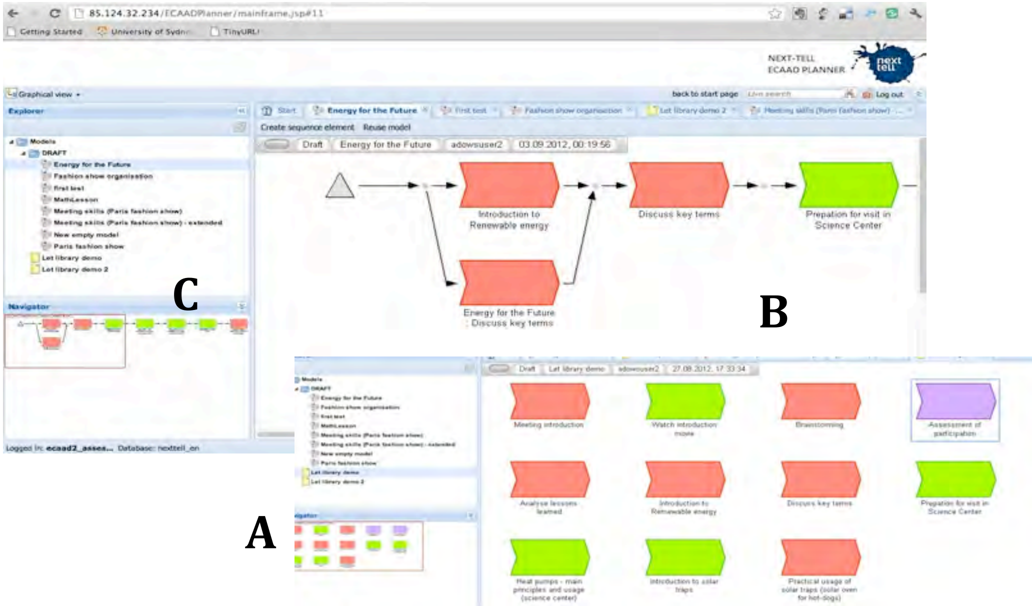

Figure 1. The graphical meeting planner. See text for explanations.

Rubrics and other forms of assessments

A number of rubrics and checklists help the teacher, and/or the students themselves, to appraise the quality of the facilitation. This is mainly done based on the artifacts that get created during the meeting planning and while running the meeting. Depending on technology and time available, as well as on the aspirations of the teacher, students can also be required to audio-record the meeting, and to analyze these recordings for learning opportunities regarding the development of facilitation competences. In any case, the appraisal is currently done manually, i.e., by teacher and/or student and/or peers, but we are also working on methods for automatic scoring of meeting activity related artifacts and process records.

Since the knowledge and skills that goes into meeting facilitation competences need to be developed across classrooms and across time, it is important for both teachers and students that they can track the development. In addition to an e-portfolio, we provide an Open Learner Model (Bull & Kay, 2010) that can be updated manually as well as automatically, provided scoring algorithms are in place, and displays competence development in a variety of formats (Figure 2). For teachers, the OLM provides access to individual as well as aggregated (e.g., on class level) competence reports. The OLM supports multiple visualization formats, and can hence also be used for discussion with individual students or the class. It further supports drilling down into the evidence layer (specific Google docs, specific e-portfolio entries).

Discussion

The user interface and the meeting activity templates are currently being refined and extended in cooperation with teaches and students, and empirical studies are being conducted in schools, in particular in second language education. These will be reported on in a later stage. There are a number of differences to other approaches to supporting online synchronous collaborative learning. We are identifying five points here. (1) The learning focus is on the student in the role of the facilitator: What she learns about group facilitation; if and what the others learn from the meeting is dependent on the purpose of the meeting and of course on the participants. We do not support assessing the content learning aspects further, but the teacher may very well. This is different from most of the work in CSCL, where the collaboration is for content learning. Our focus is on learning for collaboration, one of those "21st Century skills". (2) While the facilitation plan can be seen as a kind of collaboration script (Kollar, Fischer, & Hesse, 2006), it is different from the typical use of scripting in as much as the script is created by the students themselves (namely the one in the facilitator role) and script 'enactment' is controlled by the student in the facilitator role. We provide technology to scaffold the 'script', but under the control of the facilitating student. (3) We intentionally use a broad concept meeting activity; "argumentation" or "discussion" of "decision making" would each only be one of a number them. This because in real world meetings, multiple activities occur and gatherings are rarely structured according to a single discourse genre (e.g., formal debate). This explains why we cannot design the technical support around to a strong ontology, such as “argumentation moves” (Hoppe, De Groot, & Hever, 2009; B. B. Schwarz & Asterhan, 2011), but base monitoring and assessment on the artifacts created as a side-effect of engaging in specific activities, such as “making a decision”. (4) Even so we are building on a scenario where multiple groups work in parallel synchronously (say 5 groups of 5 students in a class of 25), our support focus is not primarily on the teacher (as in Asterhan & Schwarz, 2010, for example), but on the facilitating students. We argue that this way of “classroom orchestration” makes the job of the teacher achievable because the teacher does not have to micro-manage each group; the facilitators do that. All the teacher needs is some high-level information if the facilitation “works”, perhaps as simple as a communication channel to the facilitators so that they can call on the teacher’s support if needed. (5) We are not imposing a specific communication technology onto the teacher or school; schools are now widely equipped with propriety web conferencing tools, and/or use freely available tools such as Skype, perhaps in combination with an online tool for sharing files and documents. It is difficult to see them switching to a research tool, however powerful, or starting from a niche tool. That means, there will always be strong limits to process tracing; at least for the time being, it will be easier to capture artefacts at the file or document level, which are easily shared (e.g, Dropbox, Google Drive), uploaded (e.g., to an e-portfolio), or mailed.

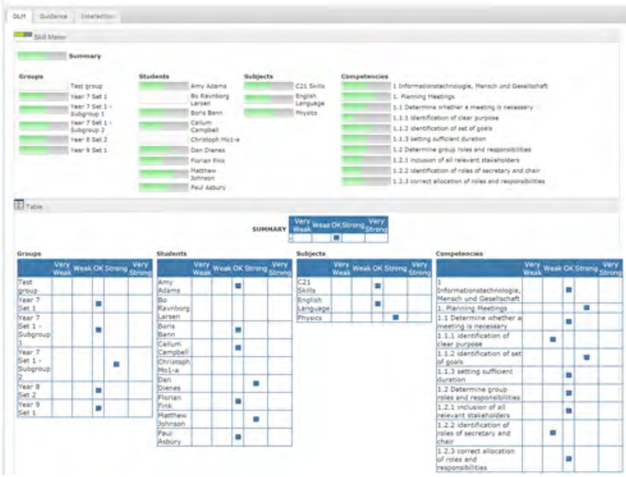

Figure 2. Partial teacher view of the Next-Tell Open Learner Model.

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Complementary Social Network and Dialogic Space Analyses: An E-discussion Case Study

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Abstract: The role of e-discussion and e-collaboration with peers in the context of problem solving has been widely discussed. Two strands of analysis, one focused on dialogic space of and key discussion events of widening and deepening, and one focused on social networking, were undertaken in a case study of a graphic, synchronous e-discussion. These approaches are shown to be complementary, as cross-analysis makes it possible to reveal interesting phenomena in the discussion and suggest directions for intervention.

Analysis of Dialogic Collaboration in Networked Environments

Socio-cultural theories of learning emphasize the construction of knowledge through social interaction. Such construction of knowledge takes place in learning situations in which students collaboratively solve a problem, combining and integrating their own perspectives, thinking and combining everyday experience with scientific thinking (Collins, Brown, & Newman, 1989). More than merely the construction of knowledge in the mind of the individual, it is a joint enculturation and meaning-making process embedded in the social context of activity (Cobb & Bowers, 1999). Adding another contextual dimension has to do with the use of information and communication technologies to support collaborative and co-operative connections between one learner and other learners, learners and tutors, and learners and resources (e.g., Dillenbourg, Schneider, Synteta, 2002).

Wegerif et al. (2008) focused on the thinking that occurs in the context of dialogues in networked environments of online collaborative learning, attempting to track the development of higher order thinking and learning skills within the ‘dialogic space’, the metaphorical arena within which dialogic discussions occur. The space of debate or dialogue (and by extension the group’s thinking) can develop via deepening, i.e. delving into an issue and increasing the degree and depth of reflection focused on it, or broadening, i.e. widening the range of relevant perspectives and relevant knowledge brought into the dialogue.

Dialogues occur within networks and use the tools, resources and affordances of these environments. Wegerif et al. (2010) illustrated how specialized ICT tools using also an AI component can help to both deepen and broaden the dialogic spaces, for example via constructing and modifying a shared external representation of a dialogue using the Digalo tool also used in this study (see further below).

Determining points or events of deepening or broadening within an e-discussion involves an in-depth analysis of the discussion’s flow and structure as well as the content of individual utterances. Other means of analyzing aspects of such discussions are available, stressing measures of participation and social interaction, making it easier to understand the contribution of each participant to the process. Theoretically, the optimal situation is that in which each of the discussants is an active participant in the discussion, whether his or her utterances lead to the development of a certain idea raised in the discussion (deepening) or is in conflict with another idea in the discussion (widening, in a sense) (McLoughlin & Luca, 2000). Researchers focus, for example, on measures of participation and interactivity such as the number of responses for each utterance, or the number of implicit or explicit links between utterances.

The leading approach to analyzing the social dimension of asynchronous e-discussions (e.g., those that take place in online forums) is that of Social Network Analysis (SNA), a key technique in modern sociology and anthropology. Using special algorithms, SNA produces schematic diagrams of the connections between individuals in a community, in which points or nodes may represent participants in an activity or discussion and the ties between them are represented by lines connecting the nodes. Measures of connectivity and other relational concepts are calculated based on data such as the distances between points in the diagram (the larger the distance, the weaker the connection). Two interesting measures in this context are closeness, i.e., the degree to which a participant is connected to other participants, and *betweenness*, the degree to which a participant connects between other people (e.g., Cho et al., 2007).

Context and Methods

The current study attempts to combine two strands of analysis, one focused on the dialogic space of group e-discussions and key events of widening and deepening, and one focused on the social network created between the participants within the activity. The presentation of the SN is based on the connectors which the participants made between each others’ contribution. In our case we didn’t differentiate between the green (supporting) connectors and the black (neutral) connectors. The two approaches we took are shown to be complementary, as cross-analysis makes it possible to reveal interesting phenomena on the relations between dialogic engagement and the way that the participants “behave” as a group in a problem solving context. This is demonstrated via a case study of a graphic, synchronous e-discussion using the Digalo/Argunaut tool (http://www.argunaut.org/).

The E-Discussion Environment

Digalo is a tool that graphically supports e-discussion and e-argumentation, which are held within an object space called a "map", where users contribute to the discussion by adding shapes representing an argumentative ontology (e.g., a rectangle for claims) and typing their utterances onto them. Users may also link shapes to other shapes, using arrows of different types (support, opposition, reference), which may be modified or deleted. This tool has been widely used in various pedagogical R&D projects in Israel, Europe and South America.

The Participants and the Activity

As part of an R&D project entitled "Network of Modeling and Formal Representation in Mathematics", 18 Colombian engineering students (ages 18-20) took part in an hour-long Digalo-based mathematical problem-solving activity, in small groups of 5-6 students each (3 groups in total). The e-discussion of one of these groups (6 students with a teacher-moderator) was chosen for analysis as case studies, due to its richness.

The problem presented to the students was as follows: *A car is traveling in the maximum permitted speed of 82.8 Km/h. When the car is 65m away from the junction, the driver sees the traffic light turn from green to yellow. The driver needs to take a decision whether to continue or to stop the car. If he decides to continue he should make sure that he crosses the junction before the traffic light turns red; if he decides to stop, he should make sure that the car stops before the junction. Consider also that that the traffic light stays yellow for 3 seconds before it turns red. If the width of the junction is 15m, the average reaction time of a human being is 1 second. Assume that braking decelerates the car at 5m/s^2. What should the driver decide, and why?*

Analysis of the Discussion Map

The discussion map was analyzed in depth using a coding schema suggested by Wegerif et al. (2008) as well as through SNA measures based on previous work done by Cho et al. (2007) and de Laat et al. (2007). The coding schema of the dialogic space enables us to identify critical moments of the discussion whereas a critical moment is identified as a point where the discussion is either widening with open questions and disagreements, or deepening with cumulative perspectives on the same problem. Beyond the analysis of critical thinking focusing on claims, counterclaims and reasons, it labels each new perspective or point of view on a problem and focuses on the dimension of dialogic engagement, which includes not only addressivity and expressions of empathy but also expressions of doubt, changes of mind, ventriloquation (the presence of another voice within an utterance) and elicitation of the views of others. Students’ style of participation was also followed by tracing individual dialogic utterances, its cumulative contributions to other utterances and its relevance to the learning outcomes of the group. The SNA measures used (e.g., betweenness and closeness that entail the geodesic distance of each actor in the net to all the others actors) give us an idea of the nature of interaction and relations within the group.

Findings

The e-discussion took about 50 minutes and included a total of 46 contributions. In the first 10 minutes, each of the six students participating in the discussion made discussion contributions that they classified as “suggestions” (e.g., “*the car should stop: if we use the equation of t=d*v it gives us more than the 3 seconds that we have for the traffic light to change from yellow to red*”), and later proceeded to connect their shapes to each other using only supporting (green) and neutral (black) connectors (connectors were also added by Mquinteroc, their teacher moderator, who did not otherwise participate in the discussion). As the discussion continued, three different threads of meaningful dialogic engagement developed (Fig. 1 below).

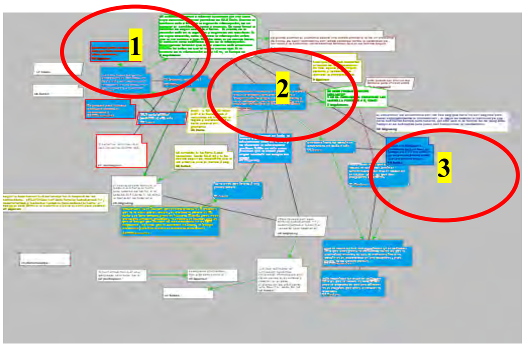

Figure 1: Discussion threads in the e-discussion map: the blue connected shapes pertain to a thread

The first thread (involving students Fmora, UCHernandez and Agalvan) discussed the calculation of speed and distance, with a widening aspect from UChernandez in contribution #14 adding the aspect of acceleration and deceleration to the mix. This is a point of widening, yet it receives no further elaboration. The second thread (UCgrozog, Jbuitragoc2 and Fmora) is a deepening thread discussing speed, distance and issues related to mathematical representation of the problem. In the third thread (Fortizb, Agalvan, UChernandez, Fmora and Agalvan), also a widening thread, the participants discuss how to represent the problem and additional elements are added and discussed (e.g., the width of the junction). Table 1 below presents the two widening threads.

Table 1: Discussion threads #1 and #3 – the widening threads

Participant	Contrib.#	Contr. type	Content
Discussion thread #1			
Fmora	6	Suggestion	t=d/v =80m/23m/s=3.47 s. if we had 3 seconds it is breaking the rules [i.e., we would have to travel faster than permitted] but if we had 4 seconds the car could pass without any problem
UChernandez	14	Suggestion	it is possible but we also have to evaluate the acceleration and the deceleration of the car
Agalvan	18	Suggestion	We can start from here but we have to evaluate the other variables
Fmora	23	Formula	82.8 km/h*1000m*(1h/3600 s) =23 m/s
UChernanadez	33	Suggestion	the time=distance / velocity
Fmora	38	Formula	he has to stop, if we look at the equation t=v*d this will allow us 3 seconds for the yellow light to turn so he will not be able to cross
Discussion thread #3			
Fortizb	12	Suggestion	Vo=83 km/h and Vf=83 km/h (the speed) is constant: 83 km/h all the time. The distance is x=65 m (if he decides to brake) and x=80 m if he decides to go on.
Agalvan	19	Explanation	My friend, I think that we cannot add up the distance until the junction (65 m) with its width (15 m), because they are two lengths.
Uclhernandez	13	Suggestion	But the sum of the two lengths is the total distance that the car has to go before the lights change. We have to take into account the units' conversion, so that we can speak the same language.
Fmora	22	Explanation	We have to take into account the conversion of km/h to m/s
Agalvan	24	Suggestion	This sum would not be the total distance because the width is immaterial for the vehicle. What is important for us is the distance that the vehicle must go.

The SN analysis of the group discussions is represented in Fig. 2 and Table 2 below. Figure 2 demostrates the interrelations between the group members based on the connections made between the participants' contributions in the Digalo map. The bold lines represent strong connections between the participants. Here we can see the centrality of Fmora, UCgrozo and UChernandez. In Table 2 we present numerical data related to the participants' rates of participation in the network with respect to the number of contributions that each of them made, and the rate of "farness" and "closeness" of each actor to the central actor in the network. These measures also quantify the importance of an actor within a network, referring to the frequency with which a node appears on the geodesic (shortest path) that connects a pair of nodes. An actor who is in the geodesic path connecting two nodes of the network has an intermediary position within the group, a person through which everybody connects to the other participants in the net.

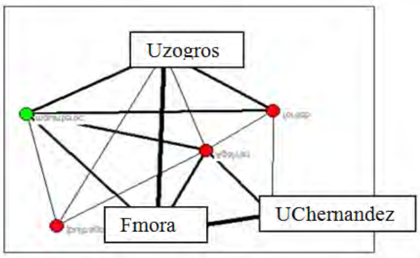

Figure 2. The social network diagram of the group

By looking at Table 2 we can identify the centrality of Agalvan in this network, with closeness of 100 and betweenness of 2.58, much more than the other participants. It is also worth noting that despite the low rate of betweenness (0.25) of UChernandez, he holds a central position in the network, as can be seen in Fig. 2. This phenomenon is interesting in light of these participants' dialogic engagement in the Digalo discussion (see Table 1). UChernandez's had an important contribution (#14) for widening the discussion in thread 1, which apparently did not receive much attention or reactions from his fellows. It is possible that the other participants did not take him seriously because of his low betweenness position in the SN. Based on pure SNA measures, Agalvan does hold a central position, but his involvement in the dialogic space entailed mainly organizational or moderator-like moves ("*We can start from here but I see that we have to evaluate the other variables*" [cont. #18 thread 1]), which in some cases contained only poor advice to solve the problem posed (as in contribution #19, in thread 3, where he tells the group that "the width of the junction and the distance that the car has to go have two distinct units of measure" (?)).

Table 2. Measures of social network analysis

Participant	No. of connections	Farness	Closeness	Betweenness
Fmora	10	8	75	0.67
Agalvan	9	6	100	2.58
Mquinteroc (teacher)	9	7	85.7	0.92
Ucgrozo	9	7	85.7	0.92
Fortizb	6	8	75	0.67
UChernandez	6	9	66.7	0.25
Jbuitragoc2	3	9	66.7	0

Discussion

The findings in our research point toward some possible advantages embedded in the comparison between, or combination of the analysis of the dialogic space and SNA. One possible direction is the joint consideration of SN connectivity measures, on the one hand, and the participants' contribution to the discussion and to solving the problem, on the other hand. As for the former, it is possible that somebody like UCHernandez is found to be central in SNA, but quite unnoticed or ignored (even if his some of his contributions were valuable) in the dialogic space, in which most of his links (connectors) with the other participants were created by him and not by them. Participation may not be enough, indeed, even if it brings valuable content to the discussion, as long as the group does not take up the contributions seriously and assimilates them in deepening and widening threads. These elements, as they find expression both in the discussion and the associated SN, may be the result of the previous (pre-discussion) character of the group and the social interrelation of its members (Cho et al., 2007). Another phenomenon is that of Agalvan. He is not the teacher (which is Mquinteroc), but he adopted a teacher or mediator-like role. He is seen as central from an SNA viewpoint, with the highest betweenness measure. When observed in the dialogic space, he shows involvement in the major strands of the discussion, especially as one that gives advice and makes comments on how to advance. He does so, however, as a mediator between other participants, providing only few elements or ideas likely to contribute to the solution of the problem. Similar phenomena have been observed in SNA of (asynchronous) forums (De Laat et al., 2007). Our approach may lead to an improvement in the way interventions take place in e-discussions.

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Flexible Gamification in a Social Learning Situation. Insights from a Collaborative Review Exercise

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Abstract: We discuss the challenges of applying a game design frame on a learning activity, through a case study of a gamified collaborative review exercise. We distinguish problems of gameplay from problems of divergence between game and non-game logics. Using Béguin & Rabardel's theory of instrumental genesis we observe how the gamification instrument shapes the review activity, in the process of continuously adapting artifacts and users' activity schemes. We identify locally emergent solutions to the divergence issue: players resort to half-engagement with the game and tailor gameplay strategies, selectively ignoring, observing or bending rules such as to manage the relative priorities of game and non-game objectives. In our case study gamification is more than an engine for fun: it facilitates learning by structuring the collaborative activity in memorable events with specific tempo, attention focus, and communication style. Constant adjustment enriches learning and becomes part of the game.

Introduction

Gaming has become a widely available reference in diverse activity contexts. Accordingly, games have become a resource for designing collaborative work and learning solutions. In this paper we investigate the design of gamified learning exercises through a case study, relying on the instrumental genesis theory of Rabardel and Béguin (Béguin & Rabardel, 2000; Lonchamp, 2012).

Gamification does not involve the deployment of a full-fledged serious game; instead, it represents a method of cultivating intrinsic motivation and intense involvement in a non-game activity, by making use of game design principles and techniques. In brief, gamification represents "the use of game design elements in non-game contexts" (Deterding, Dixon, Khaled, & Nacke, 2011).

Gamification has been a contested practice. Bogost (2011) points out that the concept itself makes the process of design seem like a mechanical, simplistic application of elements to transform an activity, thus running against the complexity of game design. Authors have proposed alternative, critical names for these practices, such as "exploitationware" (Bogost, 2011) and "pointification" (Robertson, 2012). Still, gamification has continued to gain currency not only in business ventures but also in education, and it has also grown as a research topic. These critiques have served to highlight risks for both users and proponents of games as valuable cultural forms. Our research begins with the realization that gamification is not hazard free, and that the design process must anticipate challenges and allow for local adaptation.

We look at gamification as an *instrument* that mediates a collective activity, following the theoretical framework of Rabardel and Béguin (Béguin & Rabardel, 2000). They define the instrument as an ensemble consisting of an *artifact* and users' *cognitive schemes* for working with it. Consequently, the genesis of an instrument does not refer strictly to artifact design, but includes its gradual development into an instrument-in-application, which takes place always in here-and-now situations of use. The authors distinguish two types of processes in instrument genesis: *instrumentalization*, in which the artifact is changed, and *instrumentation*, in which user schemes are adapted. We study gamification as an instrument consisting of:

a) *The gamification artifact*: it mainly consists of a structure of game-related symbolic and material elements that are used to create a *game layer* for an activity. Interface features such as avatars, levels, badges, points and leaderboards are often used; elements may also be selected from deeper levels of game design, including game mechanics (time constraints, limited resources), heuristics (clear goals, obstacles, feedback, collaboration and competition), models (challenge, fantasy) and design methods (playtesting, playcentric design etc) (Deterding et al., 2011). The gamification artifact also includes an *accessory set*, with auxiliary elements that are used to put in practice the gamified exercise: hardware and software, furniture, paper, food and beverages etc;
b) *Cognitive schemes*: they refer to participants' schemes for dealing with the gamification artifact; for example, participants may end up "using" or "playing" a gamified application (Deterding et al., 2011).

We define flexible gamification as the process of framing a non-game activity as a game, through a process of instrument design and adaptation in actual situations of activity and play. Our research question is: *What types of influence does flexible gamification have on a social learning activity*?

We address this question by examining two sessions of play in "Revision Fever", a gamified exercise for a collaborative review project, and by studying its gradual construction, as an instance of instrumental genesis (Béguin & Rabardel, 2000). Our case study relies on observation throughout the development and implementation of the "Revision Fever" exercise, on 11 interviews with different types of participants (designers, players, judges, and an observer that attended the two sessions of play without game involvement), and on analyzing the internally produced documents (correction tickets).

The "Revision Fever" exercise

Our case study is situated in a Cisco Academy Training Center, about to begin a new semester of CCNA professional courses. The instructor team had just started to plan the yearly revision of its course presentations, in order to correct various errors and improve their content. In previous years, this activity consisted in allocating presentations to individual instructors, who would correct and submit them in revised form. This work was considered tedious, and in some cases instructors seemed to do the job poorly, postponing it until the final hours before the deadline. Also, this organization of the review activity did little to stimulate learning in the instructor team; while some individual improvement of technical concepts was expected, there was no latitude for sharing knowledge between senior and junior instructors. Also, individual work did not afford a collaborative, reflexive feedback on the team's own standards and styles of elaborating course presentations.

From a coordinating position, we decided to organize this year's review as a game, specifically as a competition between teams of instructors; we designed the gamification artifact, which was implemented in the same week. The artifact, called "Revision Fever", relied on four game mechanics:

a) Group competition: instructors were grouped in 3 teams of 5 members (each including at least a senior instructor), which collectively reviewed presentations. They reported errors and solutions to a judge committee of 3 members (all senior instructors), who could approve or reject "error tickets" via the Trac 1.0 issue tracking system[(1)]. Tickets were classified in five categories (typo, graphic design, rephrasing/rewording, wrong concept, missing concept). Teams won points for each approved ticket. For example, a typo ticket (worth 1p) indicated "relability → reliability", while a wrong concept ticket (8p) indicated "The data is encrypted -> the data is not encrypted, the data is protected against modification". Points could be spent in the internal game market (see below). The exercise was organized as a 3-hour session of collective, face-to-face gameplay. The team with the highest final point score won the game.
b) Limited resources: each team of 5 members started with only one computer, one chair, and two presentations to review. Teams could then buy in the game market other computers (for 30p each), additional presentations (20p), more chairs (5p), or glasses of water (5p) and pizza slices (10p).
c) Alternative play strategies: teams could design their own strategy around key variables such as: a) division of labor; b) focus on selected types of error tickets; c) choices in investing / spending points.
d) Game self-regulation: judges were allowed to change any game rule at any time, and to adjudicate conflicts.

The first session of the game accomplished a revision of 11 presentations out of a total of 31. Teams submitted 260 error tickets out of which 208 were approved. After the first session, we have conducted interviews and, partly based on our discussions, we proposed a modified version of the game, which was implemented in a second session of review. We have also conducted interviews after the second session.

Results and discussion

We have identified two sources of difficulties when using game design for non-game activities. On the one hand, regarding *gameplay*, (some) game elements may not be experienced as meaningful by (some) participants, thus failing to create motivation and engagement. On the other hand, especially if the participants do start to act gamefully, there is a risk that the *game logic and objectives will develop at the expense of the main activity logic and goals*; for example, in-game competition may hinder requisite collaboration, or it may drain a large part of available resources. We shall illustrate both categories and the adaptive processes of instrumentalization and instrumentation through which they were addressed in "Revision Fever".

Gameplay challenges

Several elements of the game layer were not well balanced. During the first session, nobody spent points on water and pizza, since all teams opted to invest in computers and presentations; therefore, participants worked with an unanticipated degree of discomfort. More importantly, the first session struggled with a ticket bottleneck: the 3 judges were unable to assess in real time the incoming ticket flow. Because tickets were not approved, teams did not have enough points to buy additional presentations and computers.

In order to deal with disruptions in gameplay, the instrument evolved on both dimensions: artifact development and scheme adjustment. *Instrumentalization* (change of game design and other tools) was visible from early on: judges adjusted prices, and pizza (when cold) was finally distributed for free. Between the two sessions, the role distribution was changed to include 5 judges, solving the ticket bottleneck. Also, teams could buy presentations on credit. The software infrastructure of the 2nd edition added Dropbox [(2)] to the issue tracker, to allow judges to verify in real time the revised materials.

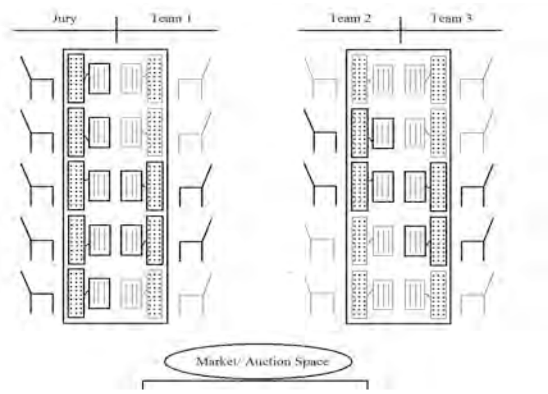
Some artifact changes were decided by judges in order to address a visible problem; others emerged spontaneously, in interaction. For example, when trying to find a rule for attributing two newly arrived senior instructors to the playing teams, in the 2nd session, the idea of an auction suddenly came forward: teams would bid with points for including an additional member for 15 minutes; the member goes to the highest bidder. Auctions then took place every 15 minutes, and they constituted, in effect, a major change in the game: teams publicly competed throughout the game, in lively verbal exchanges. Our respondents considered auctions to be the most fun element of the 2nd session.

Adjustment by *instrumentation* can be observed in the gradual consolidation of gaming attitudes and strategies. By and large, players stuck to the rules, and no individual exceptions were formally admitted; still, there were occasional instances of tolerated cheating on some rules (free glasses of water, a chair that was spirited away without payment).

Game – activity divergence and convergence

The divergence of the game logic with the review and learning logic has been a major concern from the initial design stage. This is why the first version did not require players to actually implement their proposed corrections: we feared that, in the rush for point accumulation, players would introduce other errors in the revised materials. Still, we did not reach a viable solution for implementing tickets outside the game. The second session introduced the rule that tickets be sent only after the slide is corrected, and judges were in charge of verifying slide repairs. After the game, participants evaluated this solution as effective.

Other instances of divergence were also noticed and addressed. In an instance of *instrumentalization*, judges had to declare minor typos (such as missing diacritical marks) ineligible, because players would submit them in large numbers, as a facile source of points, thus presumably ignoring more substantive errors. The 2nd session required teams to correct typos, but they could not be reported for points any more. Teams in the first session started with only one computer for all 5 members, and participants considered that it led to a period of low fruitfulness; the second version started from two computers per team.



Chair available for participants at the beginning of the game

Chair available for purchase (extra points)

Computer available for participants at the beginning of the game

Computer available for purchase (extra points)

Market: Items available for purchase

Figure 1. Organization of the RF exercise work space (second session)

We also observe an *instrumentation* process in which players and judges gradually position themselves on a continuum between engagement and disengagement with the game layer, thus managing the relative priority of the main activity (collaborative review). The resulting solution consisted in *half-engagement*: players constantly acted in ways that were at odds with the game logic, in order to review the materials meaningfully. For example, there was continuous collaboration between members from adversary teams, and between team members and judges, in order to settle technical disputes. Collaboration in the 2nd session was (inadvertently) encouraged through the accessory artifacts, specifically the gaming space: player and judge teams were positioned facing each other (see Figure 1), thus inciting dialogue.

The fast paced, competitive logic of the game visibly precluded some desirable types of larger-scale reviews: restructuring presentations as a whole (such as to eliminate redundant slides), adding a large discussion of an important topic, or rewriting a slide from scratch. In future versions, these could remain outside of the game; alternatively, they could be formulated as a higher-risk, higher-level *mystery ticket* type, with judges deciding the variable sums of reward points. This solution could also productively and non-intrusively involve the more technically minded participants that would have rather worked without the game layer.

Despite these divergent logics, or maybe through the very process of solving them, instructors have experienced the "Revision Fever" exercise as an engaging learning situation: interesting errors became topics of debate and technical argumentation, including online searches for clarifying information (besides humorous comments that led to the formulation of a "funniest errors" top). As a tentative evaluation of the learning climate, we reckon that the "error-spotting" frame, the fast pace and the competitive logic induced a lively atmosphere in which controversies had a sharper contour, and individual learning experiences were, subjectively, more noticeable. One junior instructor mentioned that she learned a lot by seeing that "it's not like that, it's the very opposite"; a senior instructor saw the exercise as a collective "debunking of technological myths in our presentations". The gamification artifact helped shape the revision work into a learning situation.

Table 1. Examples of adjustment types in "Revision Fever"

	Gameplay	**Divergence between game and activity**
Instrument-alization (artifact change): The game layer	-Balancing elements (game market goods and prices, number of judges) -New mechanics (auctions in 2^{nd} session)	-New rules (teams implement corrections) -Balancing elements (changing ticket types; two initial computers per team)
The accessory set	-Changing the structure of the error ticket to include a distinctive field for the proposed correction (in 2^{nd} session)	-Adjusting the game space (tables, chairs) -Adding software (Dropbox)
Instrumentation (user scheme adjustment)	-Evolving play styles: selective options for observing vs. bending rules, cheating, and sanctioning others' apparent cheating; opting for a more competitive (even aggressive) or collaborative style, a more gameful vs. playful style etc	-Evolving styles of engaging with the game: total engagement versus half-engagement; -Evolving styles of including de-facto non-players in the game: separate non-game tasks; specialized game tasks that do not require full engagement (mystery tickets)

Conclusions

Gamification is often discussed as a potential source of intrinsic motivation and fun. More than that, it can contribute to *structuring an activity* - inviting an attention focus, speed and rhythm, communication flows, and by creating "story-tellable" events with memorable contours. Even more, game design may stimulate unusual social interaction, reversing relations of authority (for example, by seating on the same chair a junior and a senior instructor) and affording interaction beyond usual peer groups. Thus, gamification can be an *effective facilitator of learning*. At the same time, it raises specific *challenges*: gameplay may be limping, unbalanced, and the game objective, rules, pace or style of interaction can impede the main activity goals. Last but not least, some participants may feel alienated, if not outright uncomfortable – especially when discomfort is part of the game, as in our case study.

We have witnessed significant adaptations introduced by participants during gameplay and in-between sessions, with more or less anticipation of what they would lead to. *Instrumentalization* processes involve both the game layer elements, and the accessory set. *Instrumentation* occurs when participants' play styles evolve, and also when players' engagement with the game is attuned to the task at hand. Users resort to ignoring, bending, or cheating on game rules to adjust their schemes for carrying through the gamified activity. One local solution to the issue of game vs. activity divergence consists in developing a *style of half-engagement with the game layer*: players enter and leave the game-world continuously, following the demands of the main activity; some participate only nominally throughout the entire session of play. Gamification evolves as an instrument through its actual use; these adjustment processes contribute to a stimulative learning situation.

Endnotes

(1) http://trac.edgewall.org
(2) https://www.dropbox.com

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Scaffolding a technical community of students through social gaming: lessons from a serious game evaluation

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Abstract: In this paper we present and evaluate the serious game World of Operating Systems (WoUSO), designed to scaffold an emerging technical community of students. WoUSO is a voluntary, semester-long browser game that embeds quizzes and riddles in multiple forms of player interaction. Game evaluation indicates that WoUSO creates shared experiences in which classroom learning and technical skills become resources for fun and sociability. Competition and player interaction are two main motivational engines of the game; they need to be judiciously calibrated in order to reduce incentives for rule bending, to accommodate multiple styles of play, and to diversify resources for self-presentation and positive reputations.

Introduction

There is a rich thread of experimentation with games as motivation resource in computer science education. We have found several useful instances relying on individual play to foster concept learning (Hill et al, 2003; Eagle & Barnes, 2008; Maragos & Grigoriadou, 2007). Another relevant body of research examines educational social gaming as an occasion for engaging and meaningful interactions, which cultivate communities of practice and support different forms of distributed learning (Hicks, 2010; Whitson & Dormann, 2011; Trausan-Matu, S., Posea, V., Rebedea, T., & Chiru, C., 2009). Game play supports intrinsic motivation to engage with the curriculum – although it is often the case that students are required to play the games as part of coursework, and students' performance in the game is consequential for their grade – making the game extrinsically motivated, at least to some extent.

We tackle the motivation problem from a slightly different angle. Instead of making game play a means for the purpose of getting course credits, we make course learning a means for the purpose of play. We thus propose to put to use an introductory university course in Linux as a resource for free, fun, intrinsically-motivating and socially meaningful actions that rely on technical knowledge, constitute communities and create positive school-related self-images and reputations.

Since 2007 we have developed the World of Operating Systems (WoUSO) game (Deaconescu et al, 2011), associated with an introductory BS course in Linux for Computer Science students in an European University, in a team including faculty members, students (mostly former players) and alumni, organized on three directions: 1) Content generation, 2) Framework development, and 3) Evaluation & Motivation - which we have coordinated. We present here our recent work of evaluating the 5th edition of the game, implemented in the fall of 2011.

Game presentation

WoUSO is a browser game in which students compete individually and collectively by answering sets of questions about Linux, general CS concepts, computer science history and culture, as well as more whimsical or 'geek-ish' computer-related tests. The game is an open source project, and students may log in its development interface to report bugs and suggest features. In each edition the game also enrolls out-of-competition senior players, mainly faculty members and students in the 2nd and 3rd years. Players can use computers or other mobile devices at any place or time to access the game, which means that they are in complete control of their company, technology, and any other contextual elements of play.

The game taps several motivational sources to captivate players: competition, immediate feed-back, scaffolding, humor, curiosity, social interaction and self-assessment (Maragos & Grigoriadou, 2007; Whitson & Dormann, 2011; Malone, 1981). The 5th edition also had an elaborate story for 'extrinsic fantasy' allure (Malone, 1981) and a new visual interface (see Figure 1).

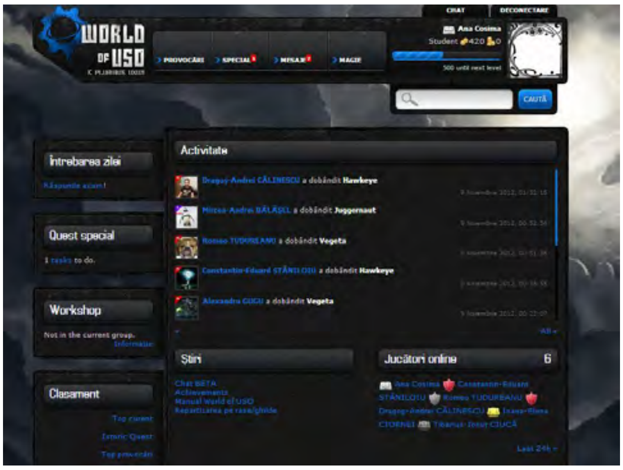

Figure 1. Visual interface of WoUSO

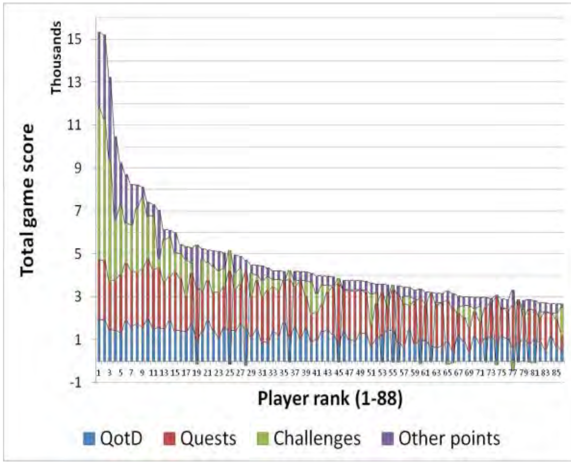

Figure 2. Distribution of total game points by source activity, for the 88 systematic WoUSO players

The main game components require different combinations of knowledge, timing and sociability for play. They are the Question of the Day, weekly quests, the final quest, challenges (duels) and special quests.

1) The **Question of the Day** (QotD) is a daily, individual, quiz-type question based on the course curriculum: “How many parameters may a bash script have?” [a) Unlimited b) None c) 1000 d) Only one].

2) **Weekly Quests** are series of weekly computer science-related riddles. There are no predefined strategies: players explore and test a wide range of interpretations and approaches, and they can also ask for hints on the game forum. Players usually have an answer time of 24 hours to complete the quest – a period in which team members attend to students’ requests for clues. For example, one quest riddle was: “baabbeb0b6b1dfacb7adbbb3aaf2f5” with the answer “ETAOIN SHRDLU” (the ASCII message was translated to binary representation, negated, then formulated in hexa representation). The **Final Quest** is similar in style but more complex, and it requires Linux configuration skills. The weekly and final quests are supposed to be played individually; in practice, though, students often solve them collectively, especially those living in dorms. Players also clandestinely communicate their solutions to friends and colleagues, contributing to the game’s social economy of exchange and generosity (Whitson & Dormann, 2011).

4) A player may challenge another one to a duel. Each participant may activate the duel within the next 24 hours; upon activation, s/he receives a set of 5 quiz-type multiple-answer questions, from the course curriculum, with 5 minutes answer time. One example of challenge questions is: “With what key combination can one enter the “Insert” mode in VI?” [a) a b) i c) eof d) q e) ESC f) ENTER]. The player with the higher score wins the challenge. In this edition a student could only initiate one duel per day – but s/he could accept an unlimited number of invitations from others.

Because duels could generate large amount of points, even up to 150 points, they have been the main battleground for those aspiring to win the game; duel scores differentiated the top players (see Figure 2). The most arduous players have also found solutions to push duels to the limits of game rules or beyond, by making alliances or by asking colleagues who were not playing to donate them their accounts, which they could then use to run fake duels. Such forms of rule bending have been, every year, a topic of controversy and also a reason of disenchantment for some players. Each edition has implemented solutions to combat point harvesting; in 2011 duels were scored in direct proportion to the ratio of loser / winner total points, thus discouraging the use of passive accounts and encouraging duels among players of similar rank.

6) The Special Quest has been introduced in 2011 to bring some off-line materiality to player interaction. It comprises ‘adventures’ such as borrowing a book from the University library, making a group photo with the coordinator of the development team, singing a song with a course professor, or getting 4 autographs from teaching assistants. Special quests are published weekly and are solved by teams of maximum 4 players, constituted by players at the beginning of the semester.

The student with the highest final score is the game winner, and the top 10 players receive special awards in a ceremony at the end of the semester. Also, there are prizes for the student series and group with the highest cumulated score. Interestingly, the winning series in 2011 did not include most of the top 10 players, winning through many lower-profile contributions.

Evaluation results and discussion

In the spring of 2012 we conducted the first systematic evaluation of WoUSO gameplay experiences, relying on

a) Our observation of gameplay, in 2011 and in previous editions;

b) A brief anonymous evaluation survey conducted after the game was completed;
c) Interviews with 20 student players and 4 team members.

Scale

Although we did not expect all students to play the game, given that participation is voluntary and completely unrelated to course assessment, we aimed to mobilize as many players as possible, in order to make the game an effective resource for casual campus talk and relationships. In search of a point threshold for measuring and comparing meaningful participation, we have decided to count players that have total scores equal or larger to a conventional level of 25% of the average of the first 10 players. This leads to an estimate of 88 systematic players in 2011, an increase in comparison to the 33 systematic players in 2010.

WoUSO as an experience of learning for fun

There are 175 students who have volunteered some open comments and / or suggestions concerning WoUSO in our anonymous evaluation survey, and 51 of these comments explicitly point to the usefulness of game play for learning, including learning the OS course content, more notions of Linux, and other knowledge of computer science and CS culture. There are only 8 comments that characterize the game as 'boring', 'useless' or 'a waste of time' – although, of course, it is plausible that this opinion is also shared by some students who did not write their evaluation. Another 4 students argue that questions were too difficult and thus unfit for 'simple beginners'. Therefore, as a rule, those who do express an opinion of the game see it in close connection to course learning; the game is said to 'stimulate the desire to learn', 'help students' development in the OS field', 'provoke users to learn more about OS', 'go through the entire course content' etc.

Besides positive evaluations, we have also expected, hoped for and received several enthusiastic comments about the game. Some students in the anonymous survey describe the game as "Addictive, useful, a good way of learning the course content"; "It was cool and it creates a type of addiction; "A good idea, interactive, a good place for making friends, creates addiction". Two other anonymous users write that WoUSO is "a captivating game which is mind blowing", "EPIC! It really is: this is all I did the entire semester and it was great: I learned a lot of new things, I made a lot of friends, it helped for my exam", and that "WoUSO was at first a shocking experiment because I didn't believe there can be so much interest from professors/TAs in the Romanian university system. WoUSO demonstrates the passion of the aforementioned and they make the faculty very attractive, in spite of its high difficulty level." We have also found such experiences in the interviews. One respondent [P3] describes the game as addictive – especially because of the challenges: "[P3] Really, you do become addicted to this thing, I mean… I know that in the last days I had a challenge, I played it, and then I looked for others that could duel with me, 'come on, isn't it that you can challenge me?'".

Game Reputations and Social Classification

Two WoUSO components contributed to the emergence of reputations: the forum, and the player ranking display. On the one hand, students posted on the dedicated game forum the results of their Special Quests – thus displaying their creativity, humor, and also skills to negotiate rule-bending, addressing topics such as: scheduling quests, fixing bugs, or unfair play. The main WoUSO reputation creation mechanism was the player ranking: the top 10 players were visible at any time on the front page of the game, while all players were ranked on a separate page, one click away.

What was the social meaning of this ranking in the student community? We can answer this question by looking at the '**types of people**' that students refer to. We notice two main interpretations of the hierarchy: some recognize it as a ranking of effort and merit, while others challenge it as rewarding unfair play. For example, students who wrote anonymous comments occasionally refer to various 'types of people' such as "those at the top", or "the interested ones". These expressions offer us clues for understanding game-related social classification and reputation. One comment, which is also echoed in interviews, says: "Although I didn't play I initially found the idea interesting, however my limited knowledge and the gap between myself and those at the top made me quit". A former player presents his game trajectory by saying that "[P2] Absolutely interesting but… at some point you lose… if in the first week you don't play it full speed, you lose a lot in the ranking and, if you are already on the 150th place, you don't feel like playing at all. But there, in top 10, they play all around, those were playing all the time, they had all sorts of discussions." "Those at the top" are thus a distinctive social category – loosely contrasted with those who lag, or drop lower in the ranking: "An interesting game, but not for those who don't keep it up", writes another anonymous student. "Those at the top" are often seen as the "best ones" [P2], or the "interested" students – contrasted to those who "don't even have Linux installed". This positive reputation of the top players is even more visible in the evaluations of the faculty and game developers; systematic WoUSO players are seen to be "[T2] people who are more competitive (…), those more involved in the things that they do in the University", and to constitute the alternative meritocracy for the OS course: "[T4] You don't get grades, but you win a score, you win a score to get to the top. Being in the top you are one of the 10 winners, the grade it's not the only [thing that counts, A./N.]… for the OS course."

Still, the overly competitive practices of the top players, who put in long hours of play and search for rule-bending opportunities that allow them a competitive advantage, make other students disappointed with game play, instantiating the "hard-core" versus "casual" player dynamics and discourse from MMORPGs. One anonymous comment says: "In the beginning I thought it's a very good idea and I still claim this, but I lost my interest because of the way it differentiates between players who know the course content and those who know how to get by". Another comment proposes that "A different scoring system should be implemented which wouldn't strongly benefit those who play obsessively".

Conclusions

The WoUSO game scaffolds a technical community of students by engaging them into a semester-long series of technical and whimsical tests and novel social interactions. Unlike other educational games, WoUSO play is voluntary and unrelated to formal student assessment, although it is closely linked with the course content. The game has attracted a systematic player community of around 88 players out of 347 registered students. Anonymous evaluations from 175 students have indicated that the game is widely considered useful for learning, fun, and a way of making new friends in the University; some of the most engaged players have even described it as 'addictive' and an out-of-the-ordinary academic experience.

One of the main motivational engines of the game is individual competition between players, locally (in duels) and globally (in the final ranking). The challenge for game designers is to carefully arbitrate it and balance it with collaborative activities. Various forms of 'cheating the system' are part and parcel of gaming for some, but disenchanting for others. In this edition, duels have been the center of rule bending but also, it seems, the most appreciated component of the game for the most engaged players. Future game development should improve duel scoring to lower incentives for fake duels, and it should foster player collaboration, for example by allowing team duels.

Because the main reputation-creation arena of the game was players' overall ranking, particularly the Top 10 list, self-presentation benefits were considerably larger for top players than for the more casual, lower profile players. Future improvements should include a wider array of formulating and making visible players' performances, on more dimensions (rapidity, perseverance, inventiveness, width of social network etc. – besides their total score), at a lower level of aggregation (per week, per game component, and per player team).

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Cooperative Inquiry as a Community of Practice

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Abstract: In this paper, we demonstrate how direct student involvement in the design of curricular interventions and educational technologies not only produces meaningful and creative designs, but also allows students to question their own assumptions about learning and to develop a deeper understanding of content. We adhered to the perspective of Cooperative Inquiry; that is, students were treated as partners in the design process. Using interview methods, we describe the perceived experiences of four student partners regarding their participation in developing a guided inquiry technology-based curriculum. We outline three major themes (*learning outcomes*, *community* and *philanthropic outlet*) and their implications for future design research.

Introduction to Cooperative Inquiry

The enactment and development of pre-designed curricula is not a simple task. In traditional models of design, people in power develop materials and expect teachers to operationalize prescribed plans (Barnett & Hodson, 2001). However, these developments routinely fail to generate impact because they do not take into account the complex interactions and culture of the classroom (e.g., Squire, MaKinster, Barnett, Luehmann, & Barab, 2003). As a result, researchers are partnering with teachers in collaborative work-circles to develop learning activities that accompany educational technologies (e.g., Penuel, Fishman, Haugan Cheng, & Sabelli, 2011). Such partnerships allow for a common understanding of the goals, core ideas, and learning principles of the curriculum and can help address concerns and tensions within implementations. While collaborations between teachers and researchers are a step in the right direction, we argue that students have often been overlooked as participants in the design of new technologies for learning (e.g., Cook-Sather, 2002). More often than we wish, adults tend to underestimate the insights and perspectives of students, particularly when it comes to making decisions about student learning (Könings et al., 2010). Many design projects continue to involve students only as testers, despite growing evidence that they can act as design partners at all stages of development (e.g., Bland & Atweh, 2007).

Participatory Design (PD) provides a mechanism to attend to student perceptions and desires during the design process. Generally, PD is used to include any design activity with an end-user; such roles include *user*, *tester*, *informant*, and *design partner* (Druin, 2002). The most involved method of PD is the philosophy of Cooperative Inquiry (CI). In CI, the user becomes fully integrated in the design process in the early stages of development. CI recasts users as representatives in work circle development teams who actively participate in setting design goals, planning prototypes, and making decisions that ensure the final design meets the needs of future users. Design partners use their experiences to assess the current design and give opinions on its shortcomings. Researchers suggest that if students are given the chance to be directly involved in making decisions on their learning and the learning of others, they might be more inclined to learn more from both an academic and a democratic standpoint (e.g., Bland & Atweh, 2007; Cook-Sather, 2002). In the present study, we examine the ways in which student designers benefit directly from participating on a large-scale technology-infused chemistry curriculum development project. Our analysis demonstrates that the use of CI can foster increasingly positive attitudes towards learning, develop a sense of community, and fulfill philanthropic ideals.

Methods and Analysis

We asked students to participate in curriculum development by having them provide feedback on written materials and ideas for the design of new simulations for teaching high school chemistry. The curriculum, *The Connected Chemistry Curriculum*, utilizes simulations modeled in a user-controlled microworld to teach chemistry at the submicroscopic level (Stieff, 2011). The simulations are paired with a structured workbook to introduce vocabulary and concepts through guided inquiry. In the beginning stages of the design process, we asked students to make important user interface design choices for the simulations. In the later stages of development, students provided suggestions for presentation of that content. The participants in this exploratory study were four freshman female students who had completed one high school science course and were currently enrolled in preparatory college chemistry. Preparatory chemistry provides remedial instruction to students seeking to enroll in general chemistry. *Kim* loved science and eagerly participated in the project. *Sarah* was excited to participate and contributed readily, but worried that her content knowledge was lacking. *Amanda* was a self-professed ‘non-scientist’ who expressed disinterest in the activities and completed activities perfunctorily. *Beth* was a pre-medicine major who enjoyed developing materials to help students transfer ideas between units.

We obtained student feedback regarding the workbooks and simulations through six three-hour interviews with a single design researcher over the course of an academic year. We chose to use a one-on-one interview process to protect the anonymity of the participants and to allow students to be candid with their responses outside the larger team. In each session, students reviewed drafts of written materials and alpha versions of software. We asked them to complete each draft activity and provide critiques and ideas for future materials. Student design partner ideas regarding workbook format and software user interface were compiled and communicated to the entire team as recommendations for revisions. Team members revised the materials and created new drafts using these recommendations. The format of each interview was loosely structured to accommodate the student design partners: some interviews began with an explicit probe of their opinions about various components of the curriculum and some interviews began with students working directly with the materials with no prompting. At the end of the academic year, each student participated in a 1.5-hour exit interview. The exit interview was semi-structured to allow each participant to comment on her personal experience as a student design partner. The exit interviews were used for the present analysis. All exit interviews were videotaped for later analysis. Each video was analyzed using a constant comparative method (Strauss & Corbin, 1994). We analyzed the videos using an initial open coding scheme that yielded the following codes: *Positive Attitude Toward Science*, *Learned Something*, *Part of the Team*, *Test Subject*, *Don't Deserve Credit*, *Used Later*, *We Listen*, *Helping Others*, *Paid*, *Tutoring*, *Appreciation for Process*, *Appreciation for Teachers*, and *Conflict/Tensions*. Three themes emerged from axial coding. The **Learning Outcomes** theme captured changes in the participants' chemistry content learning that included changes in content knowledge, attitude toward science learning, and epistemology regarding science learning. The **Community** theme captured changes in the participants' identity as designers and their sense of belonging to a community of practice. Finally, the **Philanthropic Outlet** theme captured the participants' feelings of satisfaction that their ideas and efforts were contributing to a larger project that potentially might help other students in the world.

Three Themes in Cooperative Inquiry Participation

The first theme reflects the **learning outcomes (***Theme 1***)** of the students. The students each noted that they gained skills or knowledge by participating in the design of the curriculum. First, the students expressed that they were motivated to participate because they saw the design interviews as a tutoring experience and that reviewing curriculum materials improved their understanding of chemistry. Specifically, each student noted that working with computer simulations provided a deeper appreciation for molecular phenomena. Sarah and Kim indicated that they referenced the simulations outside of the design interviews and applied them to coursework to visualize concepts. Second, the students reported gaining communication and professional skills such as offering constructive criticism and use of vocabulary. Third, all four students expressed newfound appreciations for learning science. Importantly, this appreciation extended beyond content learning to include an appreciation for how learning occurs as well as an appreciation for science teachers and text authors. Beth and Sarah voiced changes in their own understandings of the learning process in science as an iterative process. Finally, working as a student design partner in the construction of curriculum materials helped Sarah and Beth change their views of science. Sarah left the project with additional content knowledge that led to the realization that scientific knowledge was more accessible. Because she felt that the content was easier to interpret, she found science more interesting; thus contributing to a more positive view of science for her. Throughout the design process, Beth found that the content was more applicable than she had previously thought and the content knowledge she learned has applications to other careers outside the laboratory.

The second theme reflected student beliefs about **community** (*Theme 2*). This includes their view of their own role within the project, how they felt they had a voice that was heard, and whether they deserved recognition for their participation. These themes indicate that the student design partners developed a sense of belonging to a project team and a larger community of practice (Lave & Wenger, 1991) populated by individuals with a commitment to educational materials development. All members of the project team including teachers, researchers, and software developers have voiced commitments to creating new technologies and curriculum activities to improve student learning in different ways. As the student design partners' participation continued, they too began to express such commitments and a sense of ownership that they discussed in the exit interview. Student utterances in this category varied in perceived impact or influence on materials development. These students viewed the design partnership as a positive experience in which they could share their ideas in a way that could have impact. Kim even noted the partnership generated a sense of responsibility that created feelings of stress because she was invested in the project to the extent she worried about the consequences of her design recommendations. Rather than thinking of herself as a simple user or informant, Kim expressed feelings common among all members of the design work circle and acknowledged ownership of her ideas and input. Although the student design partners acknowledged that other team members heard their input and valued their opinions, they also expressed doubts about whether they deserved any credit for their participation. Language from the participants indicated that at times they felt like designers and at other times like a 'test subject.' For example, Beth felt as though any student could fill her role, but noted her individual impact when she recognized a curriculum modification based on her recommendation. Amanda suggested that she would have felt more involved had she been provided with the edited materials regularly so that she could see her impact on development. Amanda and Sarah recommended that they would feel more part of the community of practice by attending regular work circle meetings. However, Beth and Kim preferred the anonymity of the one-on-one interview setting. Despite the one-on-one interview setting, the students all expressed sentiments that they did feel as though they were part of the community with some students feeling more open and comfortable than others with the individual interviews.

The final theme of **philanthropy** (*Theme 3*) captured all four students' expressions that the interview functioned as an outlet in which their contributions would help future students learn chemistry. When students are asked for their opinions on how to better their schools, often times they will want to engage in pro-social behaviors that benefit others in their communities and will gain a sense of empowerment as a result (Thomson, 2009). We found that when we asked our student design partners for their opinions on the curriculum, they wanted to help others. Kim noted her input "could help the younger generations." Even Amanda, a self-professed 'non-scientist,' stated, "I helped people…the thought of knowing that I helped other people I feel good about it." Kim and Sarah spoke to the fact that they were uniquely qualified as students themselves to help others in this role. The students felt as though they were making a contribution and the interview was an activity that helped serve their own personal desires of philanthropy.

Discussion & Concluding Remarks

Our analysis of the student reflections about participation in a CI design project suggests that CI design not only improves the quality of designed materials and educational technologies, but that the process can engender important changes in the students themselves. While we as researchers gained benefits from their insightful views, we saw that the students gained positive aspects from our partnership. First, as seen in *Theme 1*, CI can give student designer partners more opportunities to take responsibility for their learning. During this collaboration, what becomes important is the creation of an atmosphere in which students are aware they can negotiate through dialogue, exercise responsibility, and achieve goals that have personal meaning and motivation for them (Whitehead & Clough, 2004). CI design of learning activities can help student designers to take responsibility for their learning outside of the project. Here, each of the student designers noted that through participation they not only learned more, but they became more invested in their own science learning; for some participants this included an increased interest in pursuing a science career.

Equally important, the co-designers also gained a sense of belonging through their participation (*Theme 2*) and personal satisfaction from doing work that might help other students learn science (*Theme 3*). This sense of belonging to a larger community of designers was not uniform across the students. Each student expressed surprise that her ideas were seriously considered and that they had a direct impact on materials development. Their collective position on participation suggested that they came to the project with prior beliefs that their contributions had no merit or that their contributions would be dismissed or minimized by other project team members. In fact, some students expressed this belief until confronted directly with evidence that she had made an important contribution that was carried forward throughout the design process. We believe that regardless of the student's career aspirations, developing a sense of belonging in this way is an important benefit that may last outside the project.

Despite the perceived benefits to design, adult designers and students, working with student design partners can produce tensions we must recognize and balance. Grundy (1998) argues that collaboration between researchers and teachers is already difficult and complex enough. If teachers and research designers have these dilemmas, arguably working with students is even more complicated. The capacity to have students make design decisions in an equal democratic fashion like adults can be a challenge. Often, researchers, teachers, and students come into projects with different agendas (Atweh, 2003), and university sponsors are under ethical and legal obligations and constraints to protect students (e.g., Bland & Atweh, 2007). In our case, while we protected Amanda's identity, she would have preferred to be credited for her work on the materials in a public fashion.

Similarly, students' perspectives can easily be twisted to conform to existing school traditions or adults' preferences (Mannion, 2007). To prevent us from imparting our biases over the students, we took great care to inquire about their perspectives. We strived to avoid a scenario that allowed only for superficial involvement of students (e.g., Bland & Atweh, 2007) by visibly taking notes as a student spoke and asking for clarifications. From these notes, we made changes to the curriculum and the workbooks. If researchers work with student partners in design, we recommend that designers document and credit what changes were made through students' suggestions. Although students gave many suggestions, we could not implement every idea.

We believe it is critical to describe and make clear the role of student participants. In doing so, this will help students understand that when their ideas are not used it is not meant to belittle their contributions. In conclusion, as others have advocated (e.g., Druin, 2002) we have seen that such collaborations not only enrich the products of our design efforts, they have enriching and potentially lasting impacts on the student design partners themselves. We saw that students utilized the design interviews as a philanthropic outlet, realized a way to gain content knowledge through participation, and developed a sense of community. Although researchers suggest that communities of practice are developed through face-to-face interactions with an entire group (e.g., Lave & Wenger, 1991), we found that our student design partners engaged in a design community utilizing one-on-one interviews through maintaining a student empowering role in the project, creating a professional and welcoming atmosphere, and making clear to students that we were actively listening and integrating their opinions and ideas into the curriculum.

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Information Cueing in Collaborative Multimedia Learning

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Abstract: Collaborative multimedia learning is a complex and demanding scenario. Differently coded representations, interactive components, and communication have to be managed and processed simultaneously. Focusing learners' attention to relevant information might help to reduce complexity. This study was designed to investigate whether collaborative learning with multimedia can be improved by information cueing, i.e. highlighting essential information in differently coded learning material, and by providing relevant causal relations in interactive learning material. Learning dyads were compared in four experimental groups which differed with regard to information cueing during two subsequent collaboration phases. Learning material comprised multiple static representations (phase 1) and the possibility to manipulate these representations interactively (phase 2). Preliminary results ($N = 24$) indicate that cueing relevant information during collaboration focuses learners' attention to essential aspects, helps to structure their learning discourse, and improves learning outcome.

Introduction

Collaborative multimedia learning is challenging in many ways. Learners have to identify thematically important rather than perceptually relevant information, to interrelate and mentally integrate multiple external representations (MER), to select and systematically manipulate adequate variables in dynamic and interactive visualizations (DIV), to structure collaboration in a goal-oriented way, and to manage all these tasks simultaneously in the realms of their limited working memories (Bodemer, Kapur, Molinari, Rummel, & Weinberger, 2011; Vahey, Enyedy, & Gifford, 2000).

Research suggested various methods for supporting learners in dealing with these different challenges. For instance, in order to enable learners to take advantage of the potential of differently represented information, supporting translation processes between representations has been shown to be beneficial (e.g. linking representations or providing an interactive integration task). With regard to dynamic and interactive visualizations supporting hypothesis testing (e.g., providing pre-defined hypotheses) or constructing basic representational knowledge with different static representations prior to learning with DIV showed to reduce workload and led to better learning. Regarding collaborative learning processes, providing shared representations showed to facilitate grounding processes and proved to support the identification of conflicting knowledge or opinions (Bodemer, 2011).

An instructional suggestion that is relevant for MER, DIV, and collaboration scenarios is to focus learners to relevant information of the learning material: (1) By pre-structuring content in different representations, e.g. via advanced organizers (Gurlitt, Dummel, Schuster, & Nückles, 2012) or by highlighting relevant information (*signaling*; Mautone & Mayer, 2001), and (2) by visually cueing important causalities in conceptual simulations (de Koning, Tabbers, Rikers, & Paas, 2007). (3) In collaborative settings, either applying shared external representations, that implicitly focus the learning partners' activities to the most relevant information (*representational guidance*; Suthers & Hundhausen, 2003) or providing cognitive group awareness-tools, that gather and visualize knowledge-related information about learning partners (Bodemer & Dehler, 2011) proved to guide learners' attention to relevant aspects.

The presented study is starting point of a series of three studies intended to integrate these different research fields and to systematically analyze three underlying mechanisms of cognitive group awareness-tools. This first study examines the effect of focusing learners' attention to essential information in MER-based and DIV-based CSCL. It is investigated if cueing essential information by highlighting relevant elements during MER-based collaboration and by providing essential relations during DIV-based collaboration creates affordances for focused search, communication and elaboration processes. It is assumed that information cueing (H_A) focuses the learning partners' attention to the most relevant information, (H_B) leads to more systematic interaction and communication behaviour, and (H_C) enhances learning outcome.

Experimental Study

In this study two learning partners were provided with interdependent learning material (pictorial vs. algebraic; 15 min). Afterwards they were instructed to collaboratively elaborate on statistics concepts by means of different multimedia learning material in two subsequent phases: (1) During a MER-based collaboration phase (15 min) learners were provided with material that contained formulas and a static visualization of the analysis of variance. To focus learners' attention in a meaningful way, the most relevant visual and formula-based components were highlighted visually in terms of color in two of four experimental groups (MER+/DIV+ and MER+/DIV-). (2) During a DIV-based collaboration phase (20 min) the visualization was augmented by several interactive components, e.g. dragging a group mean to increase or decrease it. Again, in two experimental groups (MER-/DIV+ and MER+/DIV+) information cues were provided by presenting the essential causal relations between variables (cf. Figure 1). Both collaboration phases were conducted using a multi-touch table, enabling face-to-face communication between learning partners.

This presentation reports preliminary analyses based on a subset of 24 university students (12 females and 12 males), aged 19-30 years (M = 21.83, SD = 2.35). Dyads of participants were randomly assigned to the four experimental groups.

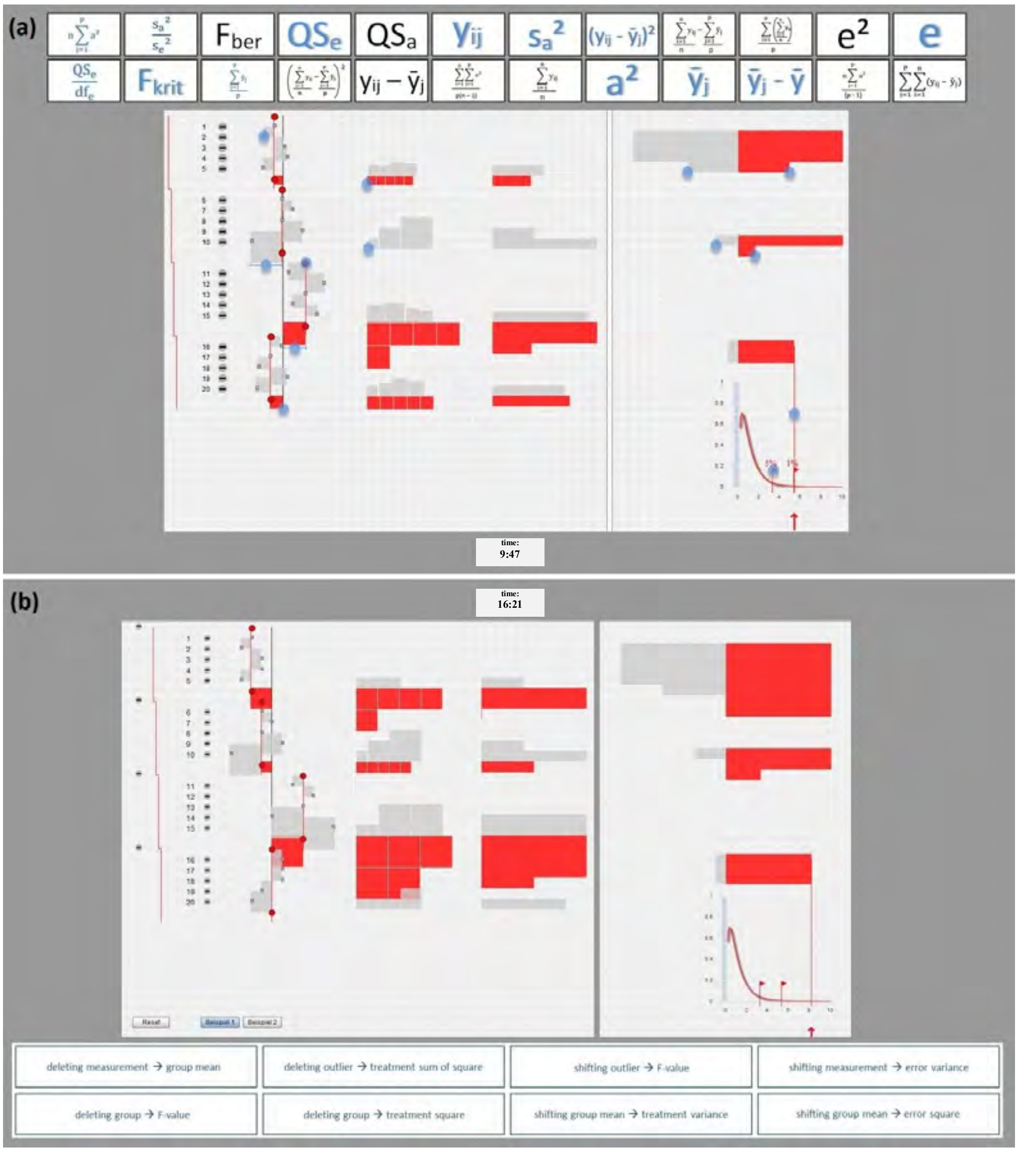

Figure 1. Screen captures of subsequent collaboration phases with information cueing:
(a) phase 1: static multiple external representations with blue solid circles and blue highlighted formulas,
(b) phase 2: dynamic and interactive visualizations with essential causal relations beneath.

Results and Discussion

Due to the preliminary nature of the data, all results are described with a more qualitative focus. After completing full-scale data acquisition, quantitative and more comprehensive analyses will be presented.

(H_A) To investigate the assumption that information cueing helps learning partners to focus on germane aspects, the number of essential concepts identified and discussed by the learning partners was assessed. It revealed that learners addressed more relevant information if they were supported by information cueing both during MER-based collaboration (M_{MER+} = .73 vs. M_{MER-} = .52) and DIV-based collaboration (M_{DIV+} = .70 vs. M_{DIV-} = .21). Additional analyses indicate that learners who were provided with information on essential relations generated and tested more goal-oriented hypotheses during DIV-collaboration ($M_{DIV+} = 9.00$ vs. $M_{DIV-} = 5.50$).

(H_B) First analyses of the learning discourses indicate that learning dyads differ in structuring their collaboration and communication depending on whether they have been supported by information cueing or not. During both collaboration phases, providing information cues led to more systematic and effective learning discourses. In the following, examples of characteristic MER-based collaboration processes with highlighted or non-highlighted learning material are given in order to illustrate the influence of information cueing on the learning discourse (cf. Figure 2).

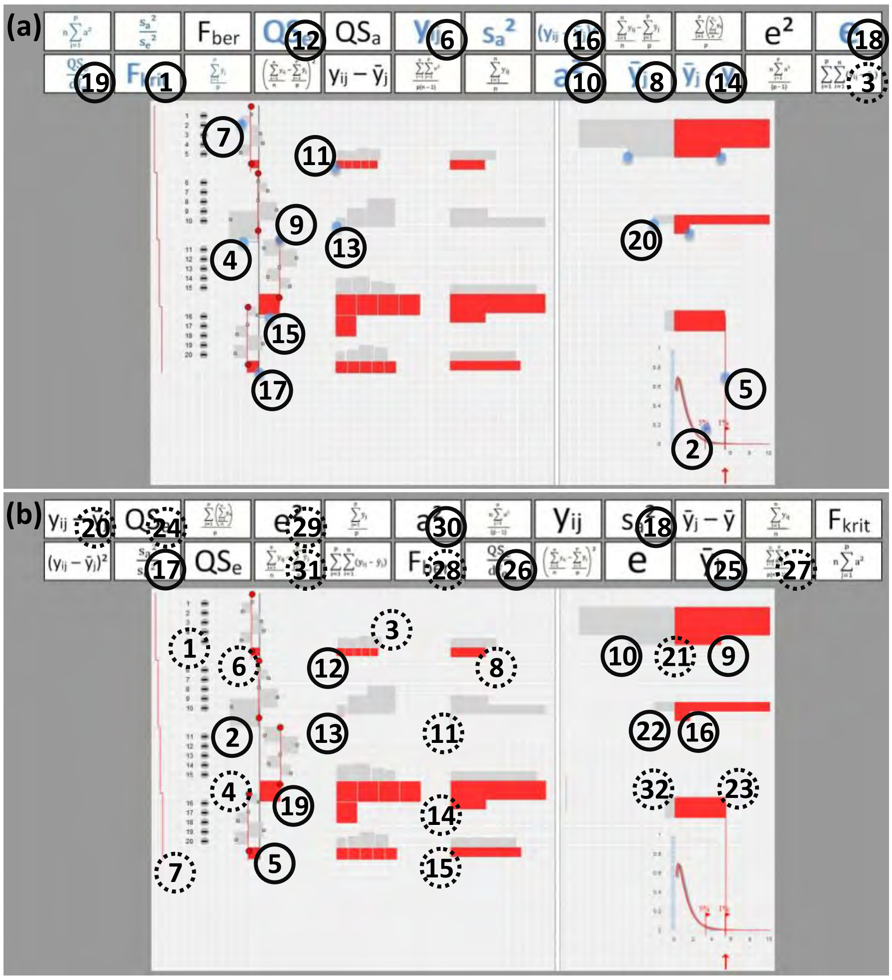

Figure 2. Characteristic MER-based collaboration sequences with (a) highlighted, and (b) non-highlighted material; numbers indicate the sequence of discussion (dashed circles indicate non-essential information).

(a) Learning partners in Figure 2a were provided with material that comprised highlighted cues to essential information. Learners showed a very good interrelation of algebraic and pictorial elements. The sequence of their collaborative learning process was well structured: at the beginning, learners discussed the critical F-value and established references between the two different representations (1-2). They continued with this systematic approach regarding all aspects of ANOVA: basic elements (4-9; measurement, group mean etc.), further crucial concepts like error and treatment effect (10-17) and, finally, different aspects of variance and their meaning for significance of results (18-20).

(b) The learning dyad in Figure 2b was provided with non-highlighted learning material. Concerning different representations, there was very little integration of algebraic and pictorial learning material. Learners exclusively explored and discussed the visualization of the ANOVA during the first half of the collaboration (1-17), before they even started to establish references between formulas and visual components (18-33). This indicates that without information cueing learners' attention is guided by other representational properties, i.e. reading direction and representational affordances of the visualization. Regarding content this dyad showed a rather linear approach at first: they clarified the more basic elements (1-7), and then discussed more complex concepts consecutively (8-17). Afterwards, learners started to integrate formulas and visual elements but, thereby, showed no systematic approach (18-33).

(H_C) Individual learning was measured in three knowledge tests which had to be performed prior (knowledge test 1) and subsequent to the collaboration phases (knowledge tests 2 and 3) (cf. Table 1 for means and standard deviations). On a descriptive level it showed that, as expected, test scores increased if learners were provided with information cues. Results regarding two subtests appear to be especially interesting: cueing information during the MER-based collaboration substantially increased test scores in representational transfer test items, whereas providing information cues during the DIV-based collaboration led to better performances on items, which were designed to quantify intuitive knowledge.

Table 1: Means and standard deviations for general and specific knowledge test scores (%).

	information cueing							
	MER-/DIV-		MER+DIV-		MER-/DIV+		MER+/DIV+	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
general test items								
knowledge test 1	33.33	17.21	37.04	16.73	42.59	14.77	42.59	10.92
knowledge test 2	46.30	16.36	53.70	12.99	50.00	11.65	59.26	9.07
knowledge test 3	47.22	14.38	58.33	15.62	60.19	23.68	70.37	15.18
representational transfer test items								
knowledge test 1	22.22	27.22	22.22	17.21	27.78	25.09	33.33	0.00
knowledge test 2	38.89	25.09	61.11	25.09	33.33	29.81	72.22	25.09
intuitive knowledge test items								
knowledge test 2	55.56	17.21	61.11	25.09	55.56	27.22	61.11	25.09
knowledge test 3	50.00	21.08	61.11	22.77	69.44	28.71	66.67	21.08

Overall, these preliminary results indicate that information cueing focuses learners' attention to essential aspects of multimedia learning material with MER and with DIV. Learning dyads provided with information cues interacted with each other and with the learning material in a systematic and beneficial way: they successfully integrated differently coded representations as well as different aspects of their knowledge.
Without information cues, learners' attention was guided more by representational properties which are perceptually relevant (cf. Suthers & Hundhausen, 2003) and less by thematically important information.

Results of this study indicate that focusing learners' attention to relevant information of learning material can reduce complexity and support collaborative learning with different types of multimedia material. Furthermore, these results might partially explain promising effects of cognitive group awareness-tools that provide social information based on essential aspects of the learning material (e.g. Bodemer, 2011).

More comprehensive analyses based on complete data will give further insight into interaction processes, differences between MER- and DIV-based learning, and potential transfer effects between collaboration phases.

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Collaboratively generating and critiquing technology-enhanced concept maps to improve evolution education

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Abstract: Students hold a rich repertoire of alternative ideas of evolution that are often quite resistant to change. One cause could be a disconnection between genotype and phenotype level ideas. Making these connections explicit might help students build a more coherent understanding of evolution. This study investigates how a novel form of collaborative technology-enhanced concept map, called Knowledge Integration Map (KIM), can support students' learning from an inquiry-based, technology-enhanced evolution curriculum. Findings indicate that KIM activities can facilitate the generation of cross-connections between genotype and phenotype ideas and support students distinguishing central ideas. Results suggest that students' used fewer non-normative teleological ideas. Furthermore, results suggest that critiquing KIMs might be a more time-efficient alternative to generating KIMs from scratch. Findings from this study are valuable for the design of efficient learning environments to support more integrated understanding of complex scientific ideas.

The theory of evolution is a unifying theory of modern biology, and notoriously difficult for students to understand (Alters & Nelson, 2002). Evolutionary theory is difficult to understand because it is, to some degree, counterintuitive (Evans, 2008). Our intuitions are formed throughout our childhood. In an early stage, children see the world filled with intentions (Piaget, Gruber, & Vonèche, 1977). Children apply this teleological understanding to biology, for example, to develop their own criteria to distinguish living from non-living things by attributing to them "needs" (goal-directed behavior) (Carey, 1985). Southerland (2001) identified "need" as a common alternative idea in people's reasoning about evolutionary change. This study explores the hypothesis that the continued use of the alternative idea "need" to explain evolutionary change is caused by a disconnection between phenotype and genotype level ideas. Students who build more connections between genotype and phenotype level might identify "mutation" as a central idea of evolution and decrease the use of the alternative idea "need". The distinction between phenotype and genotype level ideas is fundamental to the understanding of heredity and development of organisms (Mayr, 1988). To make connections between genotype and phenotype levels ideas explicit, this study implements a novel form of collaborative technology-enhanced concept map, called Knowledge Integration Map (KIM). Previous studies (Schwendimann, 2008) suggested that a combination of generating and critiquing KIMs can effectively support integrating evolution ideas, but also that the combination of activities can be time-consuming. As time in science classrooms is limited and valuable, this study aims to identify and develop more time-efficient KIM activities by distinguishing the time requirements and learning effects from either co-generating or co-critiquing KIMs. Both co-generation and co-critique of KIMs is expected to facilitate learning gains but they might differ in their time requirements.

This study aims to answer the research questions: Can the novel technology-enhanced collaborative concept map form "Knowledge Integration Map" support students' knowledge integration of evolution ideas? How can Knowledge Integration Maps track changes in students' integration of evolution ideas? Is critiquing or generating Knowledge Integration Maps a more time-efficient method to support knowledge integration?

Theoretical Framework

This study used the Knowledge Integration (KI) framework (Linn, Davis, & Eylon, 2004) as its operational framework. Students who integrate ideas across different levels might be better at distinguishing important evolution ideas from less important ones. For example, students with more integrated evolution ideas might use the idea "mutation" more frequently in their explanations than students who have a disconnected understanding. Knowledge Integration Maps are a novel form of concept maps that divide the drawing area into the evolution-specific levels genotype and phenotype (see Figure 1). Learners receive a list of ideas that need to be categorized, placed in the corresponding areas, and connected within and across levels. As each connection between two ideas can consist of only one link, students need to negotiate which connection to make. This constraint requires student dyads to negotiate and make decisions about which connection to revise or add, which creates an authentic need for effective criteria and supporting evidence to distinguish among ideas in students' repertoires (Berland & Reiser, 2009).

Methods

Curriculum design

KIM activities were embedded in a weeklong technology-enhanced inquiry-based evolution module, *Gene Pool Explorer*, which used the web-based inquiry science environment (WISE) (Linn & Hsi, 2000). As electronic concept mapping tools can facilitate construction and revision of concept maps better than paper-and-pencil tasks (Royer 2004), the java-based concept-mapping tool Cmap (Canas, 2004) has been used for all KIM activities.

Curriculum sequence: After a teacher-led introduction and KIM training phase, students individually took identical pretests and posttests delivered through the WISE environment (see Table 1). After completing the section on genotype-level ideas, student dyads either generated or critiqued a genotype-level KIM. The second section focused on phenotype level ideas. Student dyads then either generated or critiqued phenotype-level KIMs. KIMs for both groups (generation and critique) consisted of the same set of ideas and had a drawing area divided into the same evolution-specific areas genotype and phenotype to make connections within and across levels visible. Treatments for both groups were kept the same except for the two embedded KIM activities (see Table 1).

Table 1: KIM tasks

KIM task	Training (individual and in dyads)	Pretest (individual)	Embedded KIM 1: Genotype level (in dyads)	Embedded KIM 2: Phenotype level (in dyads)	Posttest (individual)
Generation group	KIM generation and critique activity	Genotype & Phenotype KIM generation and critique activity	KIM generation map 1	KIM generation map 2	Genotype & Phenotype KIM generation and critique activity
Critique group	KIM generation and critique activity	Genotype & Phenotype KIM generation and critique activity	KIM critique map 1	KIM critique map 2	Genotype & Phenotype KIM generation and critique activity

Student dyads in the *generation* group created their own connections from a given list of ideas. Generating their own connections allows students to elicit their existing and missing connections and organize ideas in context to each other.

Student dyads in the *critique* group received identical KIMs (consisting of the same ideas as the KIM generation group received) but with errors in connections and idea placements (based on common alternative evolution ideas documented in the literature). Students were instructed to generate their own criteria to review the presented KIM and negotiate with their partner how to revise the map. Generating your own criteria was expected to improve students self-monitoring.

Participants

The WISE module *Gene Pool Explorer* was implemented by an experienced science teacher in four classes in a high school with an ethnically and socio-economically diverse student population of 9th and 10th grade students (n=93). The teacher randomly grouped students into dyads. Student dyads in each class were randomly assigned to either the KIM generation (n=41) or critique (n=52) task. Students worked collaboratively in dyads by sharing a computer throughout the project.

Data Sources

This study used a pre/posttest design to measure individual students' prior knowledge and illustrate their learning gains. The tests consisted of identical multiple-choice items, short essay items, a KIM critique task, and a KIM generation task. Additionally, embedded assessment items, field notes, and teacher interview data were collected.

Analysis

Pre- and posttest analysis: Pretest and posttest items were scored using a five-level knowledge integration rubric (Linn et al., 2006). Higher knowledge integration scores indicate more complex normative links among different ideas relevant to the genetic basis of evolution. Paired t-tests, chi-square tests and effect sizes were calculated.

Multiple regression analysis and ANOVA was used to investigate whether the two KIM task groups (critique and generation) differed from each other in learning gains and changes in ideas.

This study used a multi-tiered KIM analysis method to identify students' alternative ideas about evolution and track changes throughout the sequence of concept maps: Presences or absence of connections, quality of connections, network density, and spatial placement of ideas.

KIM generation analysis used a five-level knowledge integration rubric (Schwendimann, 2007) to determine changes in quality of overall and expert-selected essential links. To capture the network characteristics of KIMs, network analysis methods were used to identify changes in the prominence (incoming and outgoing connections) of expert-selected indicator ideas: "Mutation" for the genotype-level and "natural selection" for the phenotype level. Multiplied with the KI score for each connection, a "weighted prominence score" for each of the two indicator ideas was calculated.

KIM critique analysis: KIM critique activities in the pre- and posttest included common alternative evolution ideas in three different forms (proposition error, label error, and direction error). The analysis distinguished between error detection and error correction using a four-level rubric.

Results

Pretest-posttest results: Findings indicate that students overall made significant learning gains from pretest to posttest [Paired t(93) = 6.08, p<0.0001 (two-tailed); Effect size (Cohen's d)=0.63 (SD pretest=2.24, SD posttest=2.41)]. Students in both KIM task groups (*critique* and *generation*) used the alternative idea "need" significantly fewer times in the posttest than in the pretest (t(96) = -2.67, p<0.01).

KIM generation results: Multiple regression analysis indicates that both groups gained significantly in their average KIM knowledge integration scores, R2=2.013, F(2, 88)= 11.09, p=0.000. Both KIM task groups significantly increased the number of cross-links between genotype and phenotype ideas from pretest to posttest, (N=94): Pretest Mean=2.52 (SD=1.66), Posttest Mean=1.03 (SD=1.15). t(93) = 7.49, p< .001; Effect size (Cohen's d) = 1.04. This indicates that students gained in integrating genotype and phenotype ideas after the WISE module *Gene Pool Explorer*.

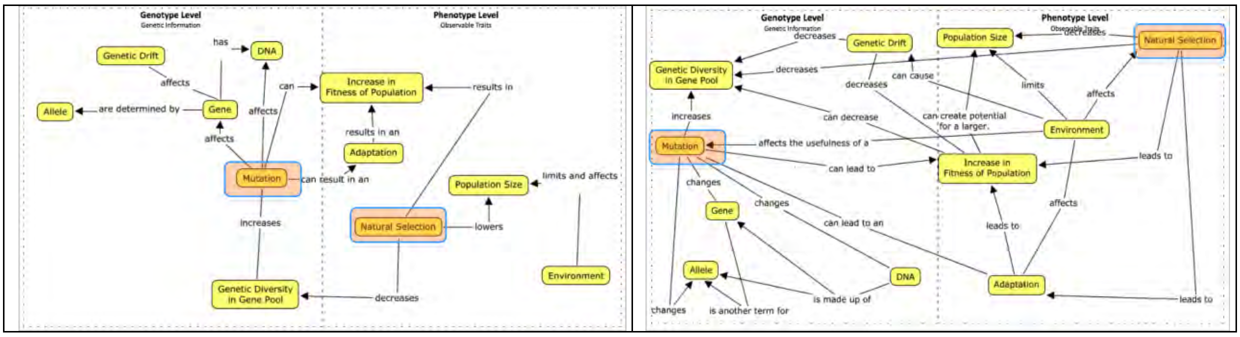

Figure 1: Example of a student's pre- (left) and posttest (right) KIM (critique group). Indicator ideas highlighted.

In accordance with gains in prominence of the KIM indicator ideas "mutation" and "natural selection", multiple regression analysis suggests that students overall used normative evolution ideas more often than non-normative ideas (such as "need") in the posttest than in the pretest (*R*2 =0.18, *F*(1,94) = 20.18, *p* < .001 (see Figure 1).

Findings from network analysis suggest that students in both groups created significantly more links to the two indicator ideas in the posttest: "Mutation" (*t*(93) = 5.39, *p*=0.00) and "natural selection" (*t*(93) = 5.83, *p*=0.00). These observations indicate that the two indicator ideas gained in explanatory strength in students' repertoire of evolution ideas. The KIM variables "weighted prominence score" for the indicator ideas "mutation" and "natural selection" are strongly correlated with the overall KIM KI score: "Mutation" r(94) = 0.75, p<0.001, and "Natural Selection" r(94) = 0.70, p<0.001. These correlations suggest that coding only the links to and from indicator ideas can be a more time-efficient way to score KIMs than coding all connections.

KIM critique results indicate that the embedded KIM activities helped both groups to critically reflect on KIMs, revisit, and revise connections between evolution ideas: R2 = 0.27, F(1, 94) = 36.25, p < 0.001.

Students in both KIM task groups spent about the same average amount of time on the pretest KIM (14 minutes) and posttest KIM (13 minutes). Both groups showed equal KIM posttest performance, but the critique group was significantly more time-efficient in the embedded KIM activities. Student dyads in the critique group were significantly faster on the embedded KIM activities than the generation group, p<0.05. (t(27)=2.72, p=0.01. These results indicate that the KIM critique tasks were more time efficient than the KIM generation tasks while leading to the same KIM posttest performance.

Discussion

Overall, findings suggest that the combination of collaborative Knowledge Integration Map and technology-enhanced learning environment WISE *Gene Pool Explorer* facilitated students' generation of connections between and across genotype and phenotype level ideas. Results support the hypothesis that building more connections between genotype and phenotype level ideas can reduce the usage of the alternative idea "need" when generating explanations of evolutionary change. Students in both KIM task groups generated more coherent links to the normative idea "mutation" in the posttest map, which coincided with fewer uses of the alternative idea "need" in posttest explanations. This study suggests that cross-link analysis and network analysis of indicator ideas "mutation" and "natural selection" can serve as a time-efficient and sensitive method to track changes in students' understanding of complex ideas, such as evolution.

As anticipated, students in both KIM task groups showed equal improvement in the posttest tasks. This could be explained by the relatively short duration of the embedded KIM activities (only about twenty minutes out of a weeklong inquiry module), the similarities of the tasks (same given ideas, same drawing areas), and that both generation and critique activities can support knowledge integration. Despite the similar outcomes, the critique group required significantly less time to complete their two embedded KIM activities. Based on quantitative results and qualitative classroom observations, the critique group might have been faster because generating new relationships from scratch can be more challenging than revising existing connections and it limits in-depth reflection to a small selection of propositions.

Critiquing KIMs that include common alternative ideas can generate genuine opportunities for students to critically reflect on their own ideas. Critiquing KIMs can encourage knowledge integration by fostering self-monitoring of learning progress, identifying gaps in knowledge, and distinguishing alternative evolution ideas. As time in the science classroom is limited and precious, this study suggests that collaborative KIM critique activities can be a beneficial and more time-efficient alternative to generating concept maps from scratch.

Significance of Work

A deep understanding of evolution is pivotal to understanding modern biology and a prerequisite to thinking systematically and critically about complex systems, continued learning about the biology, and application of biological principles in diverse contexts. Findings from this study indicate that collaborative technology-enhanced KIMs can foster the integration of genotype and phenotype level evolution ideas. Connecting ideas within and across areas is important in many areas of science and the humanities. Findings from this study are valuable for the design of effective collaborative learning activities and more time-efficient analysis methods to support more integrated understanding of complex ideas.

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Reciprocity in Student Online Discussions

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Abstract: Online discussion is a popular tool for information exchange in web-based education. Analyses of how students interact or their contribution styles can help us understand weaknesses or strengths of the participants. This paper presents a framework for capturing information trading behaviors in Q&A discussions using a 'reciprocity' model. We measure the reciprocity of a student based on (a) the degree of responses that he/she received from other students in discussing his/her questions and (b) the degree of contributions in discussing other students' problems. We use a linear regression to model the overall reciprocity rate over time, and correlate the regression coefficient of the reciprocity rate to the student course grade. We found that although the overall reciprocity rate is not statistically correlated to the grade, high performing students have larger reciprocity rates and help other students more actively. We expect that the reciprocity rates revealed from discussion participations can help instructors make online activities more balanced.

Introduction

Reciprocity, as a general concept for measuring the "trade" in social exchange, contains the common sense that giving and taking illuminate each other (Gouldner, 1960). As one of the essential and necessary attributes for the social community (Wellman, 1999), reciprocity indicates the members' behavior in the community (Herring, 2001) and maintains the stable social system by encouraging the mutual beneficial exchanges and preventing antisocial behavior (Alexander, 1987). Online learning networks, as an aspect of social life, also yield the resource exchanges (Swan and Shea, 2005). Specifically, online discussion platform is a classical application of learning networks, which supplies a platform for students to post problems they encounter during study as well as to assist other students. Reciprocity allows the online discussion works effectively by promoting students to 'give' under certain circumstances and they can also obtain help when they have problems. In previous work, reciprocity is treated as one of the "seven principles for good practice in undergraduate education" (Chickering, 1996). In addition, reciprocity belongs to one of the major motivating factors that promote individuals to contribute to online communities (Wang, 2003).

Although reciprocity requires giving and taking simultaneously, the degree of giving and taking for a group or an individual cannot be strictly identical. There is a common recognition that giving can generate more altruistic and stable reciprocity while taking yields more selfish reciprocity. Taking into account of characteristics of students, we classify them into three different groups: considerate, neutral and self-centered groups. Given the assumption that human behavior varies based on selfishness, we compare reciprocity rates among these three groups, which can provide insight on student knowledge sharing behavior (Soller, 2003). As the degree of reciprocity in learning is hard to measure, we propose a simple but effective way to define the rate between the degree of giving and the degree of taking using participation types without considering the inequality of each problem or question. We split the students into four different performance groups based on their final course grades. Such classification can facilitate an analysis of how does the reciprocity rate vary among different performance groups, allowing us to examine the relation between the grade and reciprocity.

Furthermore, we examine the change of the reciprocity rate over time within the semester. Such reciprocity trend, presenting changes in student participation styles, can assist the teacher in assessing students' contributions, comparing the performance of individuals or groups (Kapur, 2008), and detecting the cause for the change in participation styles.

Methodology

In this section, we first describe how we process discussion data. We then present a model of reciprocity in Q&A discussions. We show how the model captures the information trading behavior.

Data collection and processing

Our work takes place in an undergraduate course in Computer Science department at University of Southern California. Student grades and online discussion data have been collected from the same course taught by the same teacher in eight recent semesters, from 2006 to 2010 school year. The discussion data contain total 1,663 discussion threads and 7,164 messages. Among 370 active users, we chose 204 users who have at least two questions, so that we can capture the information trade trend over multiple questions. Given a thread, we classify which user the thread belongs to, based on the user id of the initial message in the thread. The first message in a thread usually presents a problem or a question that the user has (Feng et al., 2006). We can estimate how much help a user obtains by counting how many responses he/she gets from other users. On the other hand, we can also assess how much help the user provides to others by counting his/her replies to other users' questions.

Reciprocity rate in Q&A discussions

We examine asynchronous online Q&A forums where participants trade information by posting questions and sending answers to the questions. Reciprocity is a common activity in social life but the effectiveness of reciprocity in online education forums is not clearly observed (Edwards 2002; Halloran et al., 2002). One main reason is that relations between actors in online learning communities are not very rich especially when there is limited participation within a course. We use multiple (8) semesters' data from the same course to capture general behavioral patterns.

We define *reciprocity rate* (reciprocityR) as the ratio of giving and taking acts of a user. A user's message is classified as a giving act of the person when it responds to a question. A response to the user's question is counted as a taking act by the user. In computing the degrees of giving and taking ratio at a given time, we accumulate all the giving and taking acts until that time. More specifically, the reciprocity of user *i* at time *t* when he/she posts a question can be modeled as follows:

$$reciprocityR_i^t = \frac{\sum_t \sum_j giving_{i\to j}^t}{\sum_t \sum_k taking_{k\to i}^t}$$

where *t* is time at which user *i* posts a question. The overall reciprocity rate of the user within a semester can be computed by accumulating all the giving and taking acts in the semester. We used min-max normalization to rescale posting time ranges from the different semesters to the equal range between 0 and 1. For example, if user *i* posts *n* questions, we can calculate *n* reciprocity rates for the user, which shows how the rate change over time as the user posts more questions. Specifically, *k*-th reciprocity rate will be the rate between accumulated giving and taking acts until *k*-th question. Once we have the reciprocity at each time point for each user *i*, we can regress their reciprocity rates to capture the general trends on the time space as follows:

$$reciprocityR_i^t = \alpha_i + \beta_i t_i$$

where *t* is a value ranged between 0 and 1. In the fitted line, β_i is a slope called the regression coefficient. Such behavior trend information can be related to other variables such as student performance.

Results

Reciprocity by Behavior and Group

Figure 1 shows the distribution of each user's reciprocityR over time by his/her behavior style and performance group that he/she belongs. For performance-based grouping, we used normalized values of the course final grades since the raw grades across semesters cannot be directly comparable. We split students into four grade groups (high, high intermediate, low intermediate, and low grade group) using mean (0.82) and one standard deviation (0.08).

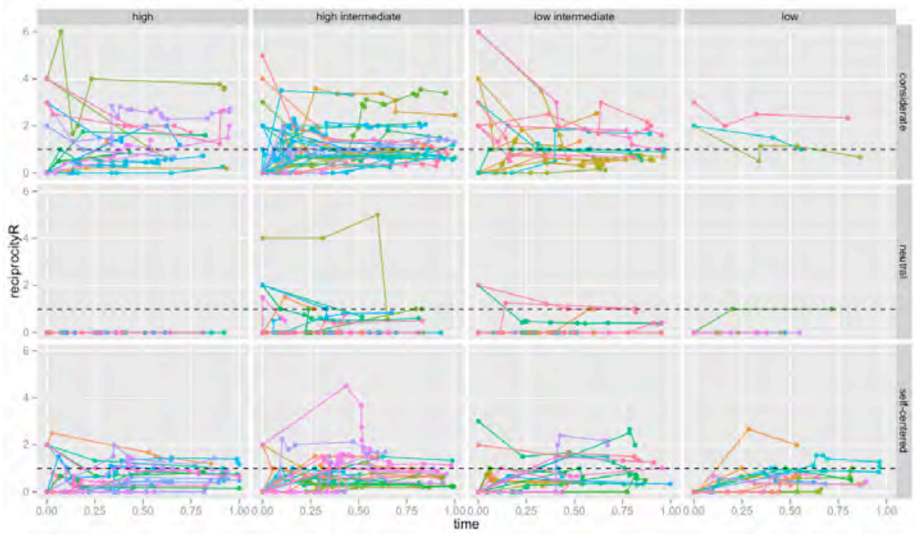

Figure 1. Reciprocity Trends by grade and behavior.

A user's responses can be split into two different types; responses in the discussions that he/she initiated and responses in other users' threads. The former represents discussion participations in answering his/her own question and the latter captures contributions to other people's problems. We use this to describe the user's behavior style. A *considerate* user sends more replies to discuss other people's problems than his/her own problems. A *self-centered* user posts more messages relevant to his/her own problems. Other users are considered *neutral*.

In Figure 1, each solid line represents reciprocityR of a user over time. A dotted line is called the "reciprocal line" since its reciprocityR is 1, i.e. the number of giving acts is equal to the number of taking acts. In the graphs in the top row (considerate group), we can observe that the reciprocitiRs of the high and the high-intermediate groups increase while those of the low-intermediate and low groups decrease over time. That is, higher performers tend to help other students. Although lower performers help other students sporadically, they stop helping before the final exam, which is located close to 1 in the timeline. In the middle second row (neural group), most lines are parallel to the reciprocity line but their reciprocitiyRs are close to zero. As shown in Table 1, those students asked fewer questions than other behavior groups and the average length of discussion threads is shorter than others. They seem to participate passively in the discussions resulting from the fact that; the number of message received from others (taking acts) is relatively smaller than the number of message sent to others (giving acts), as shown in Table 1.

Finally, in the graphs in the bottom row (self-centered group), reciprocityRs in all the performance groups increase because they present more giving acts for their own problems, which increases the numerator of raciprocityRs. Interestingly, the self-centered behavior group among the low performing students has the largest regression coefficient. They seem to concentrate on their own problems rather than others'.

Table 1: Summary of Reciprocity by Behavior and Grade

behavior	grade	N	Average						
			reg. coef	#questions	#giving for my problems	#giving for others' problems	#taking	#thread	#user
considerate	A	18	1.18	5.72	2.94	12.33	9.33	4.40	2.81
	B	34	1.11	6.76	3.12	11.32	10.53	3.37	2.59
	C	17	-0.74	5.82	2.18	8.47	12.88	3.24	2.58
	D	3	-1.14	3.00	0.00	5.00	5.00	2.47	2.22
neutral	A	9	0.00	2.89	0.00	0.00	3.56	2.56	2.37
	B	23	0.22	3.57	0.74	0.74	5.43	3.38	2.66
	C	16	0.04	3.44	0.56	0.56	5.00	2.75	2.41
	D	5	0.22	2.40	0.20	0.20	4.00	2.90	2.65
self-centered	A	20	0.76	7.85	5.00	1.15	9.60	3.89	2.55
	B	28	0.87	6.61	5.82	1.43	14.11	4.23	2.71
	C	18	0.82	5.00	3.39	1.11	7.56	3.66	2.46
	D	13	1.04	5.69	3.54	1.00	7.31	3.69	2.60

Note: reg.coef (regression coefficient)
A (high), B(high-intermediate), C(low-intermediate), and D(low)

Correlation Analysis between Reciprocity Trend and Grade

To investigate the relationship between reciprocity trends and grades, we generated a fitted line for each user with his/her reciprocityR values. We used a linear regress analysis as shown in Figure 2. Each slope, which is a regression coefficient ($\hat{\beta}_i$), represents reciprocityR trend for user *i*. As summarized in Table 1, high and high-intermediate performing group have the largest average regression coefficient. The low-intermediate and the low grade group have only negative average regression coefficients. In the graphs in the third row (self-centered group), the average regression coefficients are positive because the number of giving acts for own problems increase. Most of the high and low performing groups are either considerate or self-centered while high-intermediate and low-intermediate group members are equally distributed among different behavior groups.

Table 2: Correlation between Regression coefficient and Grade

	considerate users	neutral users	self-centered users	all users
regression coefficient	0.25*	-0.01	-0.06	0.08
N	72	53	79	204

Note: $p^{*} < 0.05$

Table 2 summarizes the result of a correlation analysis between regression coefficients and course grades. As expected, overall, they are not statistically correlated to each other because regression rate changes of the neutral and self-centered behavior groups are similar regardless of their grade levels. However, only for the considerate behavior group, the regression coefficient is statistically and positively correlated to the course grades, $r(70) = 0.25$, $p<0.05$.

Conclusion and Future Work

We propose a simple but effective model that captures reciprocal behaviors in student online Q&A discussions. The model illustrates different information trading patterns among different grade groups. We utilize a "reciprocity line" to analyze the reciprocity trends of individual users. We found that although reciprocityR is not statistically correlated with the course grade, high performing students tend to present higher reciprocity rates.

The participation styles may be related to the nature of the problem (Kapur 2007), such as difficulty and well structuredness. Besides, the change of reciprocity may be associated with the emotion the student (Muukkonen 2007). We plan to explore use of reciprocity in explaining various aspects of student online learning behavior.

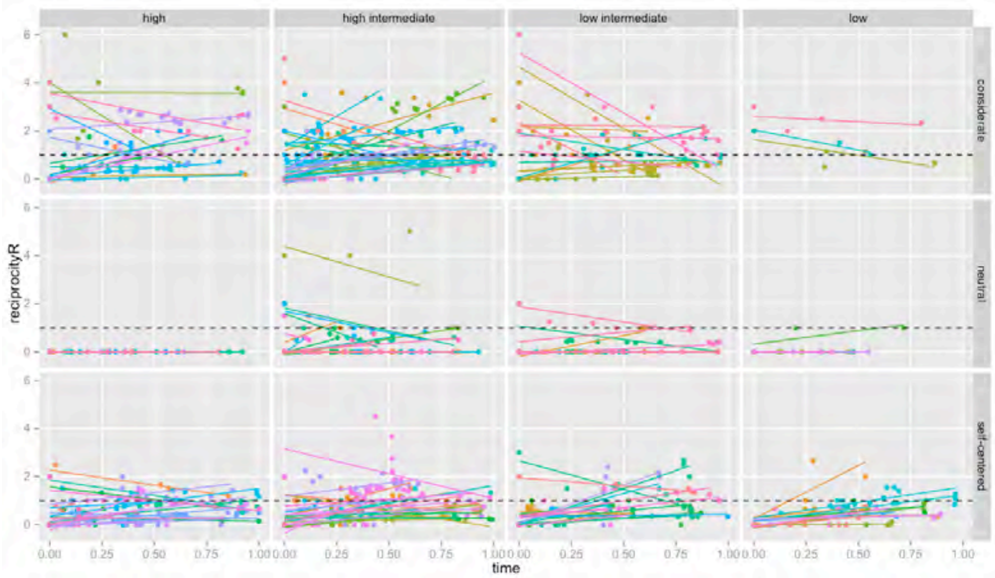

Figure 2. Regressing Reciprocity Trends by grade and behavior.

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The Contagious Effect of Dialogism with New Technologies

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Abstract: Most of the CSCL tools have been studied in short term interactions. Argunaut encapsulates many layers of ideas about dialogue and bears potential for dialogic education. In this paper, the intermittent use of Argunaut over a yearlong philosophy course is described. We focus on the trajectories of participation of two students. Two discursive phenomena are discussed: the transformation of a student, as a consequence of participation in a different group discussion, into a carrier of discursive norms previously unknown to its original peers; and the move into a multi-registered, double-voiced performance by another student. The role of the peers in these transformations is elaborated. The role of the tool Argunaut which was designed to support dialogic argumentation is also considered.

Introduction

The study of *trajectories of participation* (Ludvigsen et al., 2011) can help in understanding the interdependencies between historical and specific situations. One of the domains in which CSCL tools is by now the most popular is the domain of *dialogic teaching* (Alexander, 2004). In this paper, we analyze specific trajectories of participation in a program intended to foster philosophical activity. We used the Argunaut system intermittently. The use of the system by groups yields artifacts – argumentative maps, which can be capitalized on by the teacher and the students in subsequent activities. The Argunaut system was developed to facilitate moderation of group e-discussions with the Digalo tool (Schwarz & Glassner, 2007), a tool for enhancing dialogical teaching through argumentative practices. Argunaut provides moderators with awareness indicators and alerts, a remote control intervention panel, and classifications of important dialogue features. These aids were envisioned to help moderators monitor, evaluate, and guide discussion without disrupting the flow of the ongoing collective argumentation (Schwarz & Asterhan, 2011). Figure 1 shows some of the most important functionalities of the Argunaut Moderator's Interface.

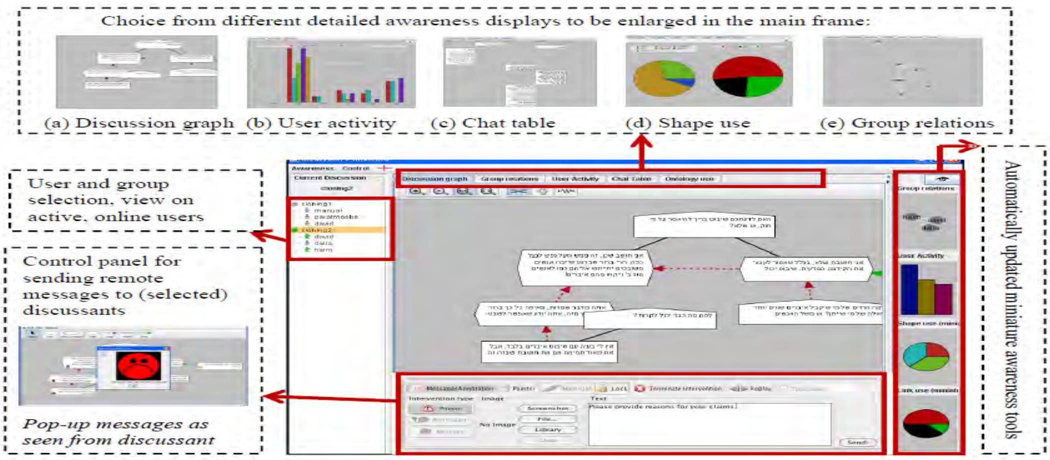

Figure 1. Argunaut's Moderator's Interface and its main features.

Most of the CSCL tools have been studied in short term interactions between users. However, Argunaut encapsulates the fact that dialogue is not only a tool for knowing but also an object to be reflected on. Like in the case of other CSCL tools, almost no study was done to describe trajectories of students in heterogeneous scales of time (for exceptions see: Ludvigsen et al., 2011). Without those descriptions, without observing the intersections of trajectories in elaborating meanings, tools and ideals miss their missions.

The philosophy course took place with 28 Grade 8 students. The school is a junior high-school whose policy is to integrate students with very different socio-economic levels. Thematically, the course was organized around three major ideas examined through its manifestations in three planes: (1) Justice, through the notion of 'inequality'; (2) Truth, through the notions of 'understanding' and 'interpretation'; (3) The Good, through the notion of the 'good conversation'. The course deployed throughout an entire year, six hours a week. The argunaut sessions were implemented as an integral part of the curriculum. Two personal trajectories are examined here: the trajectories of Yoel and Avi, who generally belonged to the same discussion group. The two are followed over three consecutive sessions. It is worth mentioning that their activity took place simultaneously with other discussion groups in the classroom.

The Analysis of two trajectories of participation

First Argunaut session. Groups were asked to read an authentic philosophical story composed by a classmate, dealing with the dilemma of stealing food in difficult times. The assignment was to describe the "great question" (as opposed to non-philosophical ones), and try to deal with it. Although their discussion lasted 17 minutes, it ended up with only one formal contribution, as Yoel is saying: "I'm alone in the conversation". But actually this utterance is not the only one: all other contributions were erased by participants, thus leaving the space empty and clean. Table 1 brings the full transcript. The numbers indicate the order of operation; the left column shows the contributions; the right column shows the deletions.

Table 1: First session's transcript

1. Avi: yoelllllll, ya stinkkkker!!	~~2. Avi: yoelllllll, ya stinkkkker!!~~
3. Avi: yoell, ya stinkkkkkkkkkkkkker!	~~4. yoell, ya stinkkkkkkkkkkkkker!~~
5. Gabby: schnitzel [wrongly writes in English letters instead of Hebrew]	~~6. Gabby: schnitzel~~
7. Gabby: Nathan Sulem [a classmate's name] loves schnitzels	~~8. Gabby: Nathan Sulem loves schnitzels~~
9. Avi: Sandra [name of a classmate's mother]	~~10. Avi: Sandra~~
11. Avi: let's crash stinker Amos.. [a classmate]	
12. Gabby: c'mmon, letz [let's]	~~13. Gabby: c'mmon, letz~~
	~~14. Avi: let's crash stinker Amos..~~
15. Gabby: Sulemmmm	
16. Avi: is it right to steal for foodd?!	~~17. Gabby: Sulemmmm~~
18. Gabby: ye[,] what[,] didn't you see Sulem doing it	
19. Yoel: why not?	~~20. Gabby: ye what didn't you see Sulem doing it~~
21. Avi: let's do super [market] today…	~~22. Avi: let's do super today…~~
	~~23. Yoel: why not?~~
24. Yoel: I'm alone in the conversation	

Second Argunaut session. Avi and Gabby were absent, and Yoel joined to Agam, Lea, and Noa, who generally collaborated as a discussion group. The session dealt with the ethical issue of ends, means, and justifications. The session lasted for 34 minutes (twice longer than the first session), and contained 39 utterances. All 39 utterances were on-task (2 out of 13 in the first). Yoel was not active. The first ten minutes consisted of a dialogue solely between Lea and Agam. They were calling for his participation vigorously: "are you alive?" Yoel remained unresponsive. Four minutes later Agam asked: "Yoel, what do you think of the story?". At the same time Lea interjected: "Yoel???". After 15 minutes of idleness Yoel wrote his first contribution: "I haven't finished rading [reading]". After another seven minutes Lea asked "Yoel, what are you thinking?" Three minutes later, as the other discussant seemed to agree upon the philosophical problem, Lea called upon Yoel again. Agam also tried to stimulate him: "so, c'mon what are you waiting for the lesson is over in a second.!!!". Yoel replied: "I finished [,] just don't have what to write", but this was neither what Lea had in mind ("what do you think about the story??."), nor Agam ("so turn on your brain and start writing right now!!!!"). Yoel responded, making a mockery out of Agam's pressure ("here [,] I wrote"). Agam kept pushing him, demanding his words about the story ("verrrrrrrry funny now writttte what you think of the storyyyy"). Only two minutes later, three minutes before the session ends, Yoel reacted: "in my opinion, he should help him". This was his final contribution.

Third Argunaut session. The session was dedicated to Singer's (2009) argument about poverty in the third world and the imperative for redistribution of global (and personal) wealth as a just consequence of it. Singer equals avoiding from active redistribution to murder. Avi, Gabby, and Yoel were teamed together again as a regular group. The session lasted for 24 minutes (13 in the first). Here is their discussion:

1. Avi: yoel, ya [you] stinker
2. Gabby: hjgl [???]
3. Avi: what's to do?
4. Yoel: need to talk about what Benzi wrote
5. Yoel: it's not fair that there are people who need to pay for other people but you can't let them starve.
6. Avi: eef [if] I didn't have money for food I would steal…
7. Yoel: but it is not considered murder
8. Avi: look left -------→ you stupid (,) it's right
9. Avi: right, it is not considered murder…
10. Yoel: is it right to steal eef [if] you don't have money for food?
11. Gabby: I also don't think it is considered murder (,) I think it is one's own right to decide what to do with his money
12. Avi: yeahhhhh… ..
13. Yoel: right
14. Avi: in sum (,) you can steal for food but only for food!

Just like in the first session, Avi started by attacking Yoel (1), but this time, Yoel is *placing a blank claim form on the conversational space and from it sends an arrow signaling critique towards Avi's accusation*. Avi deletes his utterance, and so does Yoel. Then Avi asks for instruction (3), and it is given by Yoel (4), who's also starts referring to Singer's argument (5). Avi is replying, but from reading his contribution one can only suggest he is referring to the first discussion's subject. Yoel does not seem to be aware of that as he keeps with his thinking (7). Avi is contributing a comic writing based joke, *gets no response* and keeps contributing by returning to things at stake as he agrees with Yoel former contribution. Avi, unaware of the fact there was another topic besides what he figured out to be the one, summarizes with a stark moral rule: not only he uses exclamation mark, he also enlarges the contribution form on the virtual space to an extent much bigger than other contributions. Session ends.

Discussion

Yoel was forced to move into Agam's group. Because of his different participation norms, he was exposed to pressure to participate and contribute to the joint effort of his peers. Agam's discussion demonstrated values such as serenity and directedness which were unfamiliar to him. All other peers were capable discussants; they could abandon Yoel in his passiveness, but they demanded his participation and constantly confronted him with his silence; moreover, they held him accountable for the genuine performance of the entire group. As much as their attitude failed to bear immediate fruits, indeed it changed Yoel's personal trajectory, and consequently, his group trajectory as well. As he reunited with his former group, he carried with him the directedness of responsibility for the other. As opposed to the first session, Avi harassment directed at him was not answered with silence- or with personal counter attack, but with a demonstration of disagreement with such a behavior; he uses the form of critical arrow and points towards Avi's insulting contribution in the dialogic space until he removes it. Furthermore, he takes an active role, moderating it into an on-task discourse*; he gives instructions* and responding with continuity and generalizations, trying to develop the conversation.

One of the main differences between traditional lessons to the Argunaut discussion presented is the lack of teacher-moderation in the latter. Baker and his colleagues have already showed the rise in off-topic and social-talk contributions as students of poor argumentative participation habits use a CSCL environment (Baker et al. 2011). Same students maintained off-topic and social-talk during a whole subclass moderated debate, but as debates begun, none of the above categories lasted. We argue that looseness of performance in CSCL environment is a result of the fact there was no participant to voluntarily play the moderation role usually enacted by the teacher. Some students did not identify this institutionalized voice in them, therefore did not voice it without external supervision. In Agam's discussion, the supervision was so internalized that the space was saved only to on-task contributions. This is the norm Yoel was exposed to. He witnessed how talk goes on without an institutionalized moderator and felt the group's pressure when he did not perform as expected. We see Yoel taking that role in the following discussion, acting out his recently-appropriated norm. The willing to accept the presence of the formal educational genre 'within' oneself, is a preliminary condition for entering the discussion, and this is where Yoel's importance *as discursive norms carrier* makes its central contribution, as he, an in-group member, worthy of trust, mediates the gap between genres with his way of existing in both worlds.

Avi's contributions are polarized, mostly off-topic, ad hominem and pidginized. Yet, once in a while, Avi moves into another register, uses a different function of the language and contributes on-task utterance. We argue that the Argunaut dialogic characteristics have a unique contribution to this kind of smooth movement across registers. Argunaut opened the space and afforded the tolerance towards Avi, thus contributed to the development of Avi's voice. The Argunaut system nurtures this kind of existence by doing three things: first, by eliminating the prosody of the utterances and by doing so, somewhat softens the immediate attribution of a contribution to a certain register; second, responses are always delayed, and are mediated through writing. There is a greater 'wait time' between the act of reading and the reaction of writing. The possibility of bursting at someone is mediated through the written, thus making the discursive behavior unnatural in a sense. One cannot use his old way of bursting, he needs to modify it. Third, the burden of immediate turn-taking is off: not only the response does not have to come immediately, but some utterances are not directed towards a specific addressee. Hence, participants respond intentionally after selecting what's worth replying and after formulating the appropriate response. Thus, although the utterance is ever present, it is detached from its creator, so the other participants can relate to it and can remain less obliged to the speaker. This detachment of the utterance from the speaker/writer *reduces the power of imposition* the speaker has on the other discussants, or if seen from the other side of the dialogue, it gives greater freedom to the addressees. The interesting finding here is that the described relatively detachment between the speaker/writer to the utterance has a liberating effect on certain students general contribution; they are not obliged to speak from a fixed position, they can afford themselves to be incoherent, i.e., to get involved in the on-task conversation at the same time they are keeping their old ways of talking in the conversational space.

Avi is broadening his range of contributions, becoming more engaged with task-focused activity, and *while doing so, keeps sending off-task contributions.* How does it happen? Avi addresses an insulting utterance but the pattern changes: Yoel's ignorance-that is made possible through the fact that he is remote and not having to respond immediately- serves as an opportunity for Avi to broaden his voice and try different register. All of Avi's utterances are response-oriented. Because of that, the importance of the delayed-response is crucial. Avi is capturing himself in his own prison of one-dimensional voicing, a voice of insult and harassment, especially as we place it in the context of his dialogicality, that is, his reliance on the other for the sake of getting responses. Yoel and Gabby are his points of reference and he acknowledges that. In a sense, Avi's case epitomizes the inner inadequacy between the particularity and communality (Nikulin, 2006). The Argunaut afforded ways to balance between the two, through its decentralizing effect and by changing the immediate dialogic sequentiality.

The study presented two extremely important discursive phenomena for the development of dialogic pedagogy: the emergence of discursive norms carrier and the development of multi-voicing, in a way that mediates the sometimes unbridgeable gap between the teacher's authoritative voice and the student. We tried to highlight the crucial role the Argunaut tool plays in this becoming. From a methodological point of view, the study demonstrates the vast potential trajectories of participation has when used for horizontal purposes.

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CSCL scripts: interoperating table and graph representations

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Abstract: This article shows how teachers may be offered complementary means in the form of a table representation (featuring simplicity and intuitiveness) and workflow-based representations (featuring data/work flow and scheduling).

Representing macro-scripts: tree-, workflow- and table-based approaches

CSCL macro-scripts are coarse-grained pedagogy-oriented scenarios which aim to set up conditions (guidance and constraints) to improve the likelihood that knowledge-generating interactions such as explanations and engaging in argumentation, negotiation, conflict resolution, or mutual regulation occur (Dillenbourg & Tchounikine, 2007). An example is the jigsaw script with the following pattern: first, participants individually work on a topic; second, students having worked on the same topic meet in "expert groups" to exchange ideas; third, "jigsaw groups" are formed by grouping students who each worked on a different topic in the preceding phase; finally, all students join for a debriefing session. Macro-script editing includes reflecting on the way groups are created, refining the breakdown of a task in relation to past or future classroom activities, or moving a resource from one activity to another. Script management may also require run-time adaptations. Teachers must thus be empowered to reflect on the script and adapt it before and during its enactment. This is an issue as it requires representations means to be intuitive and easy to use and, at the same time, operational and/or interoperable with complementary operational means.

Most scripting languages/editors adopt a semi-formal syntax based on trees or graphs. Tree-based representations may be found in many projects whose representational perspective is based on or inspired by XML, e.g., Reload (Reload html). Graph-based representations based on or inspired by workflow or automata representations are rather dominant; see (Botturi & Stubbs, 2007) for a review. The main advantage is that graph representations neatly capture the dynamics (dataflow and/or workflow) which is present in many scripts, and allows a straightforward operationalization with workflow engines (Harrer et al., 2009). However, although these languages/editors may be considered intuitive thanks to their graphical syntax, some works highlighted that using representations inspired from data or process modeling such as XML-like trees or process charts, which are not widespread among teachers, may be an issue for adoption (Neumann et al., 2010).

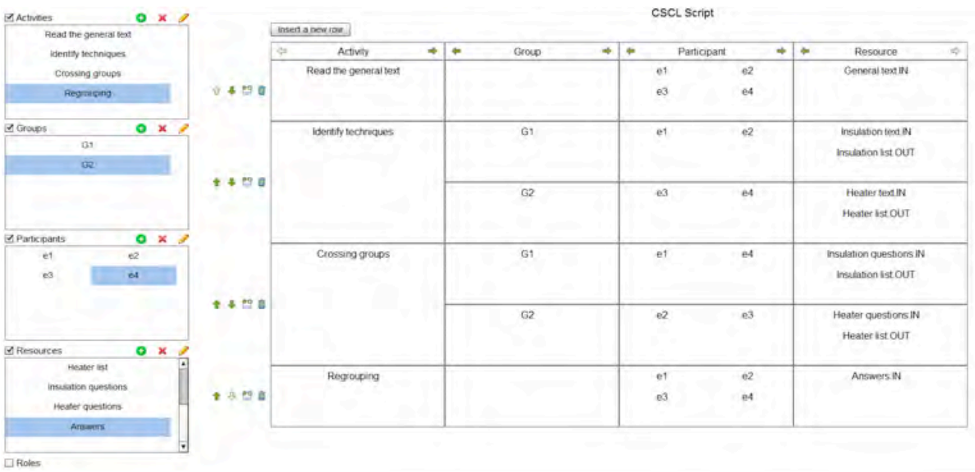

Figure 1. A script as a table, using the ediT2 editor.

An alternative approach is to offer representation means based on a structure which is known to be within teachers' basic ICT skills. This is the approach adopted by the ediT2 editor (Sobreira & Tchounikine, 2012), which represents macro-scripts as tables. Figure 1 presents its general interface, which is similar to that of a table editor in an office suite. Columns represent the activities, groups, participants, resources, and roles, notions that have been identified within a consensus effort for representing CSCL scripts (Kobbe et al., 2007). A row corresponds to a task, and can be broken down into sub-rows using splitting and merging facilities. Items (i.e. particular activities, participants, or roles) are created in the left part of the interface, and can then be dragged and dropped in the table cells. Different facilities are provided such as moving a row up or down, removing or duplicating a row (with or without its items), moving or copy-and-pasting items from one cell to another. Thanks to the table structure, a specific feature of this editor is that it does not impose a predefined representation structure: the different notions (activities, participants, etc.; or, in other words, the different columns) can be put in the order one wants, this order still being modifiable while the table is partially filled.

Teachers may thus contextually decide to use a representation pattern such as "Activity-Group-Resource" or "Participant-Role-Activity", i.e. represent a script as "a set of activities to be realized by groups sharing some resources" or as "a set of participants playing roles associated to activities". This allows teachers to adopt the structure that best fits their contextual and/or personal needs or perspective.

However, a major limitation of a table is the representation of complex sequencing of activities. Tables allow for representing linear sequences. Representation of conditions, parallelism, or loops and, more generally, intuitive representation of the dynamic dimensions of scripts require languages building on graph models.

Designing script editors leads to a classical dilemma when designing representation structures. Proposing table representations is advantageous because usability experiments and analyses of teachers' basic ICT skills show they are very easily understood and used by non-trained teachers (Sobreira & Tchounikine, 2012). However, they lack some representation power (sequencing aspects). On the other hand, workflow representations are more powerful, but require specific training. And although it does make sense to attempt to improve teachers' skills by offering advanced tools and specific training, providing teachers with such tools may be an obstacle to adoption out of lab experiences or niche settings.

One approach to this issue is to combine the advantages of multiple representations by interoperating tools. It is possible to enhance a table editor by sequencing representation means, but this breaks the simplicity of the design. As suggested by the Model Driven Engineering movement, a complex construction may rather be addressed via different models/tools offering different perspectives and advantages. In the case of macro-scripts, the advantage of such an interoperation would be to offer both (1) a specific editor providing easy, flexible representation of some aspects of the scripts, and (2) another specific tool for representing and implementing complex sequencing. This is an alternative to attempting to merge different representations within a single interface, with risks of overly-complex or poorly-intuitive interfaces.

Within this perspective, we have researched how to transform a table representation (as produced by the ediT2 editor) into a workflow. In line with the objective of contributing to interoperation of tools, we have used the jBPM model (jBPM html). jBPM is a freely available open source workflow engine that provides building blocks to describe the order in which a series of steps need to be executed. Examples of these building blocks are timers, events, composite nodes, start and end nodes, split and join nodes for branching and synchronization, operation nodes that can be associated with code, fault nodes corresponding to issues in the process, and for-each nodes to implement repetition mechanisms. This keeps the ediT2 table editor focused on what it is designed for (easy and flexible representation), representing other aspects (complex scheduling) in another specific and designed-for tool (here, the jBPM tool), which may itself be interoperated with other tools.

Transforming a table representation into a workflow

Transforming a table representation into a workflow is a model mapping issue. It requires linking the editor's representation structure and the workflow's notions, and generating from the editor a structure that can be read by the workflow editor. We will consider here the Activity-Group-Participant-Resource pattern (a script is defined as a set of activities achieved by groups, these groups being formed of participants that have access to, and produce, resources). ediT2 allows other patterns but, thanks to its formal internal representation, it can automatically transform a representation using a pattern into the one corresponding to another pattern.

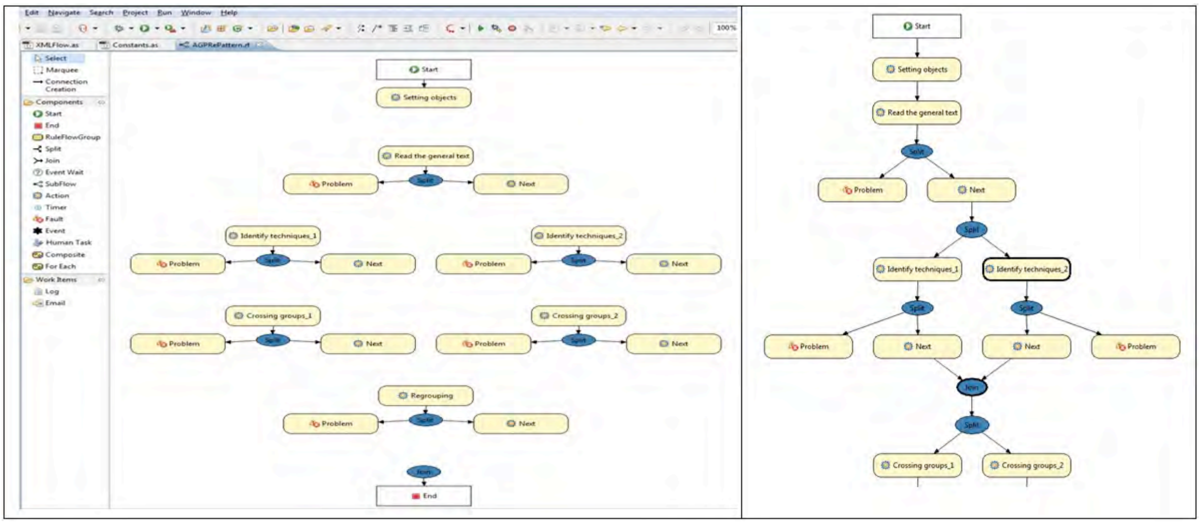

Figure 2. The workflow skeleton generated for the script presented in Figure 1.

The implemented process for transforming a table representation into a flowchart is based on the following algorithm (other solutions are possible). (1) A "Start" node and an "End" node are automatically created. The “Start” node is linked to a “Setting objects” operation which contains the code automatically generated to set the different objects’ values, e.g., the list of students per groups. (2) Each activity is transformed into a set of three operations. The first one corresponds to the activity itself (e.g., “Read the general text”). It is connected via a split connector to a “Problem” operation (which denotes the state to be reached if the activity fails) and a “Next” operation (which denotes the state to be reached if the activity succeeds). (3) When an activity is associated with *m* different groups (or sets of participants), it is automatically broken down into *m* operations which correspond to the *m* instances of the corresponding activity. For example, in the jigsaw script as represented in Figure 1, the “Identify techniques” activity is associated with two groups G1 and G2; this is translated into two instances of the “Identify techniques” operation, one corresponding to G1 and the other to G2. (4) An initial graphical position is set for the different operations and their associated connectors, ordering the operations by the table top-down structure and juxtaposing multiple activity instances if any (see left part of Figure 2). Once the table representation is over, it may be exported by pressing on an “ediT2tojBPM” button. This generates an XML file corresponding to a jBPM representation of the workflow skeleton. Technically, this transformation, which is far from trivial, is implanted by analyzing and manipulating the ediT2 script machine representation, which is a tree data structure. This skeleton can then be visualized and completed (e.g., representing repetition, parallelism or crossing mechanisms) through the jBPM interface manipulation (Figure 2, left side). Figure 2 right side presents a completed version. What is obtained is a language similar to MoCoLADe (Harrer et al., 2009), i.e., a workflow-based language. Going from a workflow representation to a table representation is also possible but would, in general, lead to a loss of information.

Using the workflow representation

A first use of the obtained workflow representation is, basically, to complete the initial design. A second one is to configure an enactment framework. A script represented as a table structure only (i.e., relying on a basic sequencing corresponding to a linear sequence of activities) may straightforwardly be operationalized on repository-like platforms such as Moodle. This may be achieved in different ways, implementing an *ad hoc* mapping or using an intermediate system that can link the editor representation to the framework meta-model, e.g., GLUE!-PS (Prieto et al., 2011). When considering a script based on complex scheduling, however, the operationalization must be conducted from the workflow representation and implemented in a framework that can reify the resources flow (access to data and tools according to the script and not as a group of resources available at any moment). From this perspective, it has been shown how a workflow representation may be used to automatically configure workflow-like platforms such as CeLS (Harrer et al., 2009). Another use of the workflow representation is testing some of the script’s characteristics by playing it as a simulation (i.e., indicating the activities flow and their associated features such as users or resources).

Let’s consider this simulation aspect. Several authors have raised the fact that teachers could benefit from simulations to refine parameters such as grouping or the flow of activities (Harrer et al., 2009; Weinberger et al., 2008). For instance, given a large number of students, it can be difficult to identify how to pair students. A possible approach is to model students’ profiles, form groups, and simulate the script enactment (i.e., make the computer compute the fact that activities “fail” or “succeed” depending on students’ profiles). The “fail” and “succeed” criteria may be defined in different ways.

As a proof of concept, we adopted the following trivial modeling (which aims to exemplify the approach and, indeed, is not meant as an advance in students’ cognitive modeling). Each student is associated with two normalized values per activity instance: activity-skill and activity-peer-collaboration. In a similar way, each activity instance is associated with two threshold values related to skill and collaboration. Given a group formation (*n* students) and an activity instance, the simulation calculates (1) the group workforce and (2) the group collaboration, and compares them to their respective thresholds to decide if the activity instance is considered as achieved or not:

(1) $$groupWorkforce = \sum_{i=1}^{n} activitySkill_{student_n}$$ (2) $$groupCollaboration = \sum_{i=1}^{n} \frac{\sum_{j=1(j \neq i)}^{n} activityPeerCollaboration_{student_i student_j}}{n-1}$$

Given the formulas to be used, the code for the different operations is automatically generated from the ediT2 interface to the jBPM XML representation. Each operation is associated with the corresponding activity’s list of students as defined in the ediT2. Therefore, once the different values have been edited the simulation can be launched. The process goes from one node to another following the different join and split connectors, the group-workforce and group-collaboration formulas, the students’ activity-skill and activity-peer-collaboration values, and the defined thresholds (all these features being easily modifiable). If an activity fails, the flow reaches the corresponding “Problem” node and stops the simulation; if it succeeds, it reaches the “Next” node. “Problem” and “Next” nodes are associated with some code to print messages on the console. Figure 2 (right side) shows an example of execution. The different operations are highlighted one after the other, whilst messages are printed on the console: “*Activity: Read the general text (Participants: e1, e2, e3 and e4; Resource: General text.IN) performed with success!*”; “*Activity: Identify techniques_1 (Participants: e1 and e2.*

Resources: Insulation text.IN and Insulation list.OUT") performed with success!". In Figure 2 (right side), the process is stopped on the join connector because the activity "Identify Techniques" for G2 has failed; message in the console is: "*Activity: Identify techniques_2 (Participants: e3 and e4; Resources: Heater text.IN and Heater list.OUT) failed because the skill summation (0.7) is less than the workforce threshold (1.0)*". Other groupings (new skill, collaboration, or threshold values) can be edited and tested similarly. The simulation can also be adapted by, for example, modifying the connections and/or the criteria attached to the join or split nodes.

Conclusions

Offering a large variety of tools that can be interoperated is, in our opinion, an important condition for CSCL basic practices to develop. The contribution of this article is to show how teachers may be offered complementary means in the form of a table representation (featuring simplicity and intuitiveness, but arguably lacking means to represent scheduling) and workflow-based representations (featuring data/work flows and scheduling, but arguably more complex). More generally, it goes into the direction of providing teachers a large offer of representations means to choose from. Users interested by an all-in-one framework (but imposing a predefined perspective) may use a LAMS-like system. Users interested by a simple representation may use an ediT2-like system. Users interested by a workflow representation may use a framework natively offering such a representation (e.g., MoCoLADe) or take advantage of a table representation (which offers a different perspective) and then extend it via workflow representation (e.g., using jBPM, but another option could be Freestyler and/or a direct translation into MoCoLADe). Operationalization may be addressed within a repository-like platform (e.g., Moodle) or a workflow-like platform (e.g., CeLS). Figure 3 shows how some of these tools may be interoperated. Effective and seamless interoperation requires engineering work, but research efforts (from which the work presented here) have shown the feasibility.

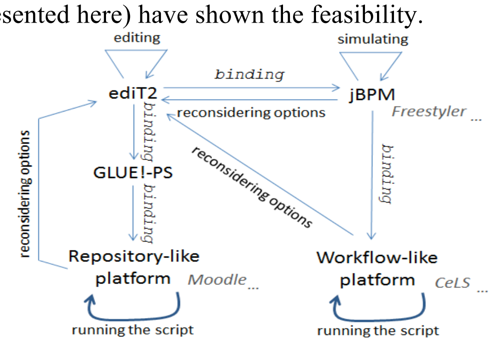

Figure 3. Interoperating different tools.

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Students' Capacity for Autonomous Learning in an Unstructured Learning Space on a Mobile Learning Trail

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Abstract: This research study investigates learner autonomy in the unstructured learning space on a mobile learning trail. Specifically, we examine how students leverage on knowledge resources and the physical affordances of the outdoor learning environment, to pursue their line of inquiries. Adapting Fischer and Mandl's (2005) coding scheme for the content dimension, we coded two groups' discourse, to examine the use of knowledge resource types. Analysis showed that contextual resources and the interaction with the physical affordances play a significant role in learners' capacity to see relations between given case information and new conceptual knowledge, as well as, activating prior knowledge resources. Overall findings indicate that autonomous learning rests essentially on the learning design, the appropriate measure at pre-structuring, as well as, student-and-teacher readiness.

Introduction

Building on our previous research efforts on small group collaborative learning in inquiry-based mobile learning (Tan & So, 2011), this study takes a step further to explore students' capacity for *autonomous learning* (Little, 1995) in unstructured learning space on an inter-disciplinary mobile learning trial. Here, we give emphasis to creating the conditions to support learner autonomy, where the entire learning environment be conceived as a whole in the design approach. Specifically, our research question reads:

- RQ 1. What type of knowledge resources do students use, in pursuing their line of inquiries/ hypotheses in the unstructured learning space on a mobile learning trail?
- RQ 2. To what extent do the following design constructs impact students' capacity for autonomous learning in the unstructured learning space?: a) task type & level of pre-structuring (we conceived of learning objectives, task-type and level of pre-structuring as mutually constitutive, as such, these shall be investigated as a whole); b) technological mediation.

Research Methodology

Research Context

We defined an unstructured learning space on a learning trail as a white space, designed with specific desired learning outcomes and is set apart for learners to pursue their own line of inquiries, leveraging on the physical affordances of the trail site, with minimal teacher supervision given the level of pre-structuring and scaffold support. Participants are two classes of secondary two students at one of the Singapore future schools. The mobile learning trail and the unstructured learning space took place at the Singapore River. To examine more closely the use of knowledge resource types and the impact of trail design on autonomous learning, we observed two groups of students from each of the two classes. Group A consists of four students and group B, five students.

Design Considerations

A Contextualized Learning Design

We employ a process-oriented framework (Strijbos, et al., 2004) to scaffold and to support learner autonomy. First, we position the learning trail as part of the larger continuum and the phasing in of an unstructured learning space was to enable greater learner autonomy in context, as aforementioned, learners can only exercise autonomy within legitimate frames of reference. Pre-to-post trail activities were co-designed by the research team and the collaborating teachers from the Geography, History and Biology department, to see how the three subjects can lend content to each other in the trail activities. To scaffold and support students learn process, collaborating teachers guide the inquiry-based learning trail by observing a gradual progression from well-structured task-types (performative and applicational) to less-structured task-types (knowledge generative and synthesis). Further, to facilitate the integration of conceptual understanding of the three different subjects on river, civilization and change, an overarching big question on "why does civilization begin at the mouth of a river?" was put in place. Pre-trail lessons on famous rivers in the world serve as a tune-in, as well as, a platform for students (in groups of four to five) to develop own line of inquiries relating to the big question. Likewise, the trail tasks at the three learning stations along the river, form part of the efforts at pre-structuring and scaffolding of learner autonomy. Students, in small group of fours or fives, were given thirty to forty minutes to pursue their pre-trail inquiry along the river vicinity, after completing all trail activities. Post-trail activities was a measure for follow-up and debrief, allowing groups to share their findings, and attempt a 'rise-above' phase of the knowledge building progressive inquiry cycle.

Technology Mediation

The appropriation of technological tools to support learner autonomy in the unstructured learning space lies primarily in two considerations: one is the requirements of the task types in relation to the trail site; two, is the students' comfort level with the mobile devices and software applications. As an initial study to investigate students' capacity for autonomous learning, the deployment of mobile technologies is, hence, viewed in the context of the learning design, desired learning outcomes, and with the intent to empower students to take on "user-led education", creating their own content with peers beyond the four walls of the classroom. Each small groups of four to five, was equipped with two iPads and two data-loggers and probes (to measure the water condition). And to reduce the physical presence of the teacher and frontal loading of information, all trail activities are hosted on the web-based platform (see Figures 1 & 2). Students were also able to host all their findings and collated artifacts (pictures etc.) on the web-based platform. The provision of the broadcast alerts and feedback features seek to enable immediacy of teacher facilitation and inter-group communication on the mobile learning trail.

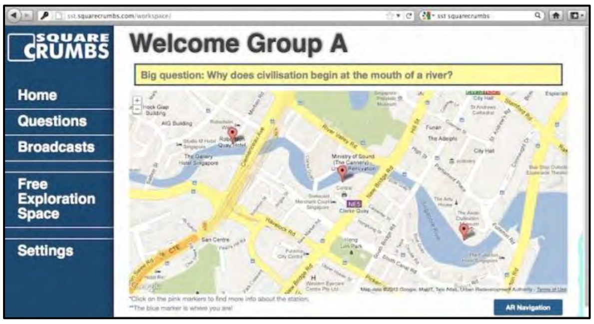


Figure 1. Web-based platform hosting all trail activities and customised Google map of trail site

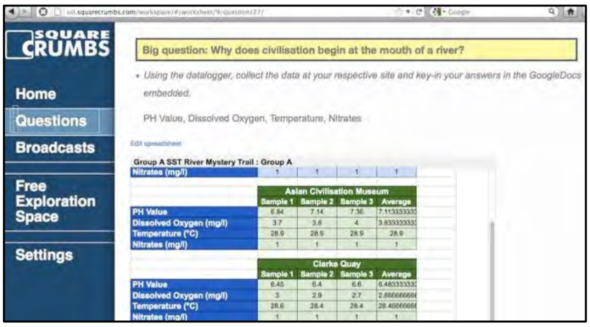


Figure 2. Well-structured task on measuring water conditions at three different sections of the river

Data Collection and Analytic Approach

Group discourse and interaction of the two experimental groups, A and B, was video- and audio-recorded and transcribed (app. 38 pages in total) for analysis. Excluding non-task talk and the sporadic private conversations, we studied and analysed a total of 113 segments of content- and task-related statements (questions statements inclusive) in the group's discourse - pursuing their inquiries and hypotheses in the unstructured learning space. Chi (1997) proposes the use of semantic boundaries to determine the unit of analysis as an idea may require a few sentences to put across, and moreover, similar idea could be surfaced several times by team members who are more vocal. Hence, each of the 113 segments forms a unit of analysis and may contain one or more than one statements/ question statements depending on the discussion threads, ideas and turn of talks. To ensure consistency and validity, three rounds of coding were conducted by the first author.

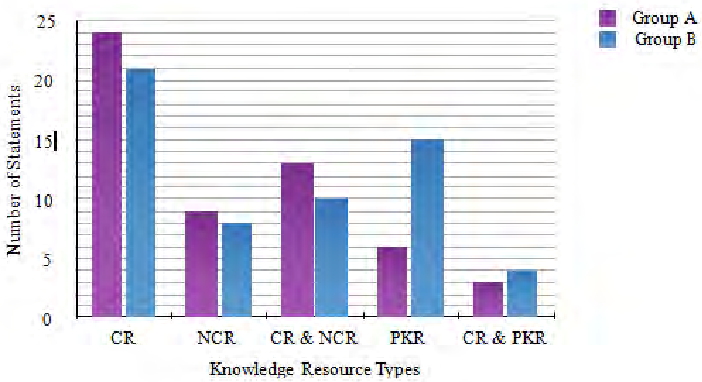
We adapted the coding scheme for the content dimension from Fischer and Mandl's (2005, p. 416) where they investigate the knowledge resource types learners leverage on, in the group discourse. Fischer and Mandl (2005, p. 406) argue for the significance of "transactivity in discourse" and the need to investigate how learners build on and advance one another's ideas to negotiate and to converge at shared meanings. More specifically, they proposed an investigation of how learners leverage the knowledge resources available and accessible to them, ranging from prior knowledge to given contextual resources, to collaboratively create and construct new knowledge and meanings. There are five categories of knowledge resources that learners use in the unstructured learning space, pursuing their inquiries and hypothesis: (1) Contextual Resources (CR), (2) New Conceptual Resources (NCR), (3) Relations Between Contextual Resources & New Conceptual Resources (CR & NCR), (4) Prior Knowledge Resources (PKR), and (5) Relations Between Contextual Resources & Prior Knowledge Resources (CR& PKR). Considering the mobile learning context and the learning design for our research study, we define contextual knowledge (case information) as resources made available at the pre-trail activities, the overarching Big Question, as well as, the trail activities at the trail site, and by theory text, it refers to the integrated conceptual understanding of the three subjects, Biology, Geography and History and Biology on river, civilization and change.

Findings

A Comparison of the Frequency of Knowledge Resource Types Used

Table 1 depicts the frequency of the range of knowledge resources both Group A and Group B tapped on, in the course of pursuing their line of inquiry in the unstructured learning space. Both groups showed relatively high usage of contextual resources as compared to other knowledge resource types. Another noteworthy finding is, students display the ability to develop new conceptual resources arising from harnessing contextual resources, as well as, the interaction with the physical environment of the riverside. Further, they were able to draw connections between contextual resources and new conceptual resources.

Table 1: Frequency of Knowledge Resource Types Used in Group Discourse



One distinguished difference between both groups lies in the activation and application of prior knowledge resources. Group B generated significantly higher number of statements (question statements inclusive) harnessing prior conceptual knowledge (ref to Table 3). We attribute this phenomenon to the nature of Group B's pre-trail inquiry on the "*timing* of the clean river campaign in the 1980s" and their hypothesis on possible significant events that could have impacted the phasing in of the clean river campaign. Contextual resources in the physical environment were insufficient for their line of inquiry. Likewise, student's capacity to develop and affirm new conceptual resources and/ or see relations between these resource types, became unwittingly contained within the availability and accessibility of the options and resources at the learning trail. Analysis of the discourse moves in the group's discourse and field notes showed them making reference to significant events and developments in the Singapore during the researched period, and affirming these inferences with authoritative sources on the Internet, before they could eventually converge at shared understanding. Conversely, group A's pre-trail inquiry on "what happened to the Singapore River as a trading point, and why it was removed and what is it now?" afforded them greater leverage on contextual resources and the physical affordances of the river site to affirm their new conceptual resources, and to draw valid inferences between contextual and new conceptual resources. The application of prior knowledge resources was also rendered more effortlessly. Similarly, it was easier for the group to identify and affirm relations between the contextual resources and the prior knowledge resources.

Impact of Learning Design and Physical Affordances on Use of Knowledge Resource Types

Pre-trail tune-in activities on famous rivers and the introduction of the big question on "Why civilization start at the mouth of a river", serve as an essential platform for students in small groups to generate their line of inquiry and hypothesis, they intended to pursue. Albeit that the eight groups from the two classes formulated varied inquiries and hypothesis, yet their intended research inquiries fall within the parameters of the big question and the integrated conceptual understanding of the three different subjects on river, civilization and change. However, the scope and subject matter of the various groups' inquiries do determine to a considerable measure the knowledge resources types they are inclined to use in their group discourse - negotiating and affirming findings and new conceptual understanding as exemplified in the case of Groups A and B, where the latter activated more prior knowledge resources to make valid inferences to their inquiries.

Noteworthy is also the *immediacy* and *interactive* feature of the knowledge resource types that students are able to identify with and make reference to. Trail activities ranging from well-structured tasks on measuring water conditions to ill-structured tasks on importance of water quality also form a significant component of the contextual knowledge resources students could leverage on, in the unstructured learning space. Table 3 shows a high usage of contextual resources in contrast to other knowledge resource types. A simple reason is the "*immediacy*" of this measure of contextual resources (trail activities that take place prior to the unstructured learning space) and the "*currentness*" of the interaction with the learning environment where learners are empowered to develop new conceptual resources and to draw sound relations between contextual resources and their new conceptual understanding. The same is also true for the activation and application of prior knowledge resources and the relations they make between contextual resources and prior knowledge resources as shown in the discourse moves. Students' capacity to draw valid inferences is largely contingent on the "sense of place" to make sense of the contextual resources, and importantly, on the interaction with the physical environment to apply prior knowledge resources.

Role of Technology in Learner Autonomy Support

The analysis of the groups' discourse shows technology assumes more than a mediatory role in some instances. It depends on the type of knowledge resources, learners deploy. Google map of the trail site (see Figure 1) with location pins indicating the three learning stations affords students a "sense of place" in relation to the vicinity and the surrounding. Both groups displayed a heavy reliance on the Google map to locate environmental artifacts for evidences to support their hypotheses and affirm findings to their inquiries. For Group B, the Google apps enable location mapping and navigational possibilities (e.g. directions, bearings, distance and scale) to test their hypothesis on the clean river campaign and possible significant events. Further, for Group B in particular, in the absence of the physical presence of teachers, they made use of the authoritative sources via the Internet to affirm their new conceptual resources relating to the contextual resources. Likewise, the application of prior knowledge resources was made possible via technology-mediated cognitive tools to confirm their inferences.

Discussion and Conclusion

Our findings carry two important implications/ challenges on promoting learner autonomy in the context of collaborative mobile learning. First, we do not ascribe autonomy to the learners, rather, we prescribe, and we do so, by means of designing the learning situation and scaffolding their learn process. The staging of the learning continuum from pre-to-post trail was a necessary and pivotal measure to facilitate the execution of the unstructured learning space and to provide learners with the cognitive autonomy support. For instance, the rich integration of the three subject areas in the design of the activity questions and the framing of the big question on civilization and river, serve as crucial cognitive support for the learners when they become agents of their own learning in the unstructured learning space. Second, the efforts of prescribing learner autonomy do not rest solely on an excellent learning design, as the student and teacher readiness remain issues of challenges. Promoting student autonomy is contingent on promoting teacher autonomy for the teacher possesses the content and the professional expertise to determine the scope and the measure in releasing autonomy to the learners by appropriating the relevant scaffolds and creating the learning conditions (Little, 1995). Students exhibited hesitations and uncertainties in affirming their findings and inferences, as they still perceive the final endorsement from the teachers as a legitimate source of confirmation of the direction they are taking.

Although we witnessed some promising results in this initial research study on learner autonomy in unstructured learning space, we acknowledge that there could be limitations such as the integration of other disciplines whose cultural and social practices differ with changing learning contexts. However, we are persuaded that promoting learner autonomy calls for more than a situation of integrating state-of-art technology into teaching and learning. It necessitates the orchestration of the entire desired learning situation for the desired learning outcomes.

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Visualizing and Analyzing Productive Structures and Patterns in Online Communities Using Multilevel Social Network Analysis

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Abstract: What does the social network structure of productive online communities look like? We present findings from a study that examined this question in the context of a popular Java programming help forum. Using techniques informed by social network analysis, we leveraged Gephi™ to visualize the social network of the online community and identified a core group of active help-givers central to the community. We then performed network motif analysis and found that a small selection of network motifs or patterns constitute the main building blocks of the entire network..

In this short paper we highlight two approaches for assessing learning interactions and participation in online communities. First, we demonstrate the viability of social network analysis (SNA) as an analytical tool in our study of an online community for programmers learning the Java language. SNA enabled us to identify the existence of a core group of users who enjoy high level of reciprocal ties and are the top participants within this open, voluntary community. Our investigation shows how SNA can be used to delineate different interaction patterns within a help forum resulting in a deeper understanding of learning and knowledge construction. Second, our study identifies productive structures and patterns of interactions that work within the context of a help-forum. Specifically, the sheer number of interactions between the core group of help-givers and a relatively large number of help-seekers necessitates the identification of the structural sub-communities that are formed around individuals of this core-group of help-givers.

Background

With the advent of the internet, learners of the Java programming language can now take their learning beyond the classroom by drawing on a variety of online learning platforms such as Usenet, MOOC and online discussion forums. Amongst the mentioned technologies, online discussion forums have flourished and attracted hundreds of thousands of learners who collaborate to increase their computer programming proficiencies and contribute to constructing knowledge for communal benefit (see Table 1 for an overview of participation statistics of the four main Java online communities). The large numbers of online discussions that take place in these forums indicate that they are potential sites of learning with significant reach.

Table 1: Participation information of four main Java programming online communities

Online Community	Membership	Post Count	Year of Establishment
Java Section of Oracle Forums* (forums.oracle.com) (*Site of study)	995,000	1,457,000	2001
Java Ranch (javaranch.com)	262,000	2,753,000	2000
Java Forums (java-forums.org)	40,000	306,000	2007
Java Programming Forums (javaprogrammingforums.com)	29,000	92,200	2008

Background

One useful methodology for examining interactions between learners in online communities is social network analysis (SNA). This multi-level approach, scholars argue, can help provide a better understanding of individual embeddedness in structural patterns (Frank, 1998; Powell et al., 2005). Social network analysis has found increased acceptance within education due to its ability to shed light on multiple levels of analysis and scholars have called for more network research in education (Hallworth, 1953; McFarland & Klopfer, 2010). A multi-level approach, for instance, helps to connect higher level of organizations – school districts – with micro level classroom data. Over the past few years social network analysis has gained popularity in the CSCL community (Jeong & Hmelo-Silver, 2010). In this context, social network analytics allows one to gain insights into the practices of a social group and can illuminate interactions within structural networks of learners (Haythornthwaite & de Laat, 2010; Suthers et al., 2012).This analytical method enables one to evaluate the nature of interactions between learners to understand the impact of learning activities so that informed instructional decisions can be made (Haythornthwaite, 2008). Overall, social network analysis is an innovative area of research with unique application within the context of our research as it is particularly pertinent for understanding learning analytics at multiple levels of analysis.

Method, Setting, and Analysis

We examined an open online help forum for Java programming language where an online text-based discussion forum facilitates voluntary and open asynchronous discussion oriented towards newcomers' explication of their learning needs. As there are limited studies conducted in out-of-school voluntary educational settings such as online discussion forums, it is helpful to highlight the distinctions in contrast with the formal classroom environment. First, the structure of the online community is informally construed and help is mainly provided by a core group of volunteers. Second, participation and collaboration is voluntary and not mandated by coursework. Third, the task structure in this study deviates from the common set-ups of common wrapper/starter roles and open-ended class discussions without pre-designated roles. In this educational setting, a help-seeker starts a discussion soliciting help from other community members who may emerge as voluntary help-givers to assist them with their learning needs. The data collection procedure involved parsing downloaded web data using Perl scripts and storing them as a relational database. The discussion forum comprised of 37,472 discussion topics created between 2001 and 2010. The activities over these forums were captured and a User information dataset contained details about all the registered users posting within the forum during the given time frame in addition to the replying user ID. We used this data to develop the dataset required for social network analysis (for details see: Mitra, 2011). The Gephi™ software (Bastian, Heymann & Jacomy, 2008) and Hu Yifan's Multilevel Layout force-directed algorithm (Hu, 2005) was leveraged for visualization purposes.

Community Structure

As demonstrated in Figure 1, the force algorithm has been applied to the entire network and the visualization in Figure 2 indicates the presence of a small core group of help-givers with high degrees of interactions with other community members. Given the positions of these core help-givers, it suggests that the community is highly reliant on these individual for their expertise and voluntary efforts.

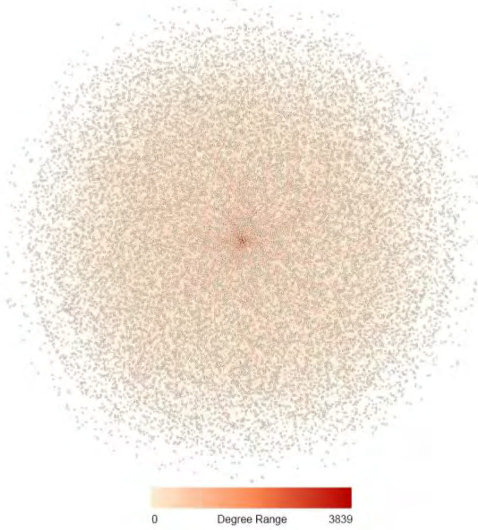


Figure 1. Network visualization of entire community

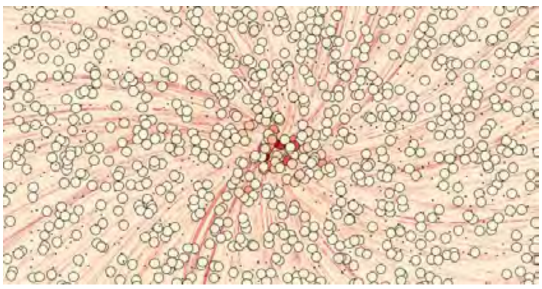


Figure 2. Close-up of visualization reveals core group of help-givers

Table 2 describes the main network properties such as the total number of mean in/out degree and network diameter. There are a total of 21,509 nodes and 125,944 edges for this network. The average path length for the network is 3.253 where the clustering coefficient, which indicates how embedded the nodes are in their neighborhood, is at a relatively low value of 0.335 and indicate that the network has relatively sparse connections. These figures suggest that the social groups in this community are not tightly connected to each other which may be a consequence of deriving the social network from standalone discussion threads.

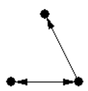
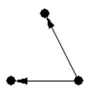
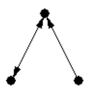
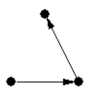
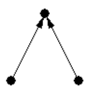
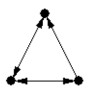
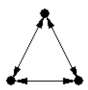
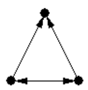
Table 2: Main Social Network Properties

Nodes	21509
Edges	125944
Mean Degree	5.981
Network Diameter	17
Average Path Length	3.253
Clustering Coefficient	0.335

Network Motifs

One formal – empirical and conceptual – avenue for understanding relationships in a community is "Network Morifs". Network motifs has been proposed by Milo et al. (2002) as recurrent patterns of local inter-connections that occur in complex networks at frequencies that are significantly higher (reflected by the Z-score) than those occurring in randomized networks with equivalent number of nodes, in degree and out degree. Motifs can be small subgraphs of typically 3 to 7 nodes and represent the basic building blocks of most networks (Milo et al., 2004; Mangan & Alon, 2003) to provide insights into the topology of complex networks (Juszczyszyn et al., 2008; Kastan et al., 2004). Referring to the motif network analysis (see Table 3), we found that the "branch with one mutual dyad" motif (M14) and the branch motif (M6) make up approximately 63.5% of all recurrent patterns in this community.

Table 3: Frequently Occurring Motifs from Network Motif Analysis

ID	Motif	Frequency [Original]	Frequency [Random network]	S.D.	Z-Score	p-value
14		43.2%	43.2%	3.284e-005	11.1	0
6		20.3%	20.2%	2.665e-005	49.7	0
164		6.0%	5.9%	4.479e-005	17.6	0
12		5.5%	5.4%	3.085e-005	32.5	0
36		0.6%	0.6%	1.583e-005	4.9	0
174		0.3%	0.3%	3.633e-005	2.2	0.007
238		0.2%	0.0%	4.840e-005	37.9	0
46		0.1%	0.1%	1.114e-005	39.6	0

The network motif M14 represents an interaction triad that suggests that a learner is engaged in a bidirectional interaction with one helper and a unidirectional interaction with another. Specifically, the latter two actors are not interacting with each other in this triadic interaction and in contrast to the fully reciprocal motif (M174), the motif is not complete. M6, as the second most frequently occurring motif, can be inferred as learning system with one actor having two unidirectional interactions. This finding is not surprising considering that each help discussion will usually involve helpers engaging in unidirectional interactions with the learner to assist the help-seeker with the learning task at hand. The dominance of the two motifs M14 and M6 suggests that a large number of interactions are not complete in this help-seeking online community. On the other hand, highly connected motifs with more than 2 edges such as M36, M174, M238 and M46 occurred less frequently and this finding suggests that interactions between help-givers and help-seekers are seldom reciprocal in the help discussions.

Conclusion

In this paper, we leveraged both social network analysis and motif analysis as a multilevel assessment approach to examine learning interactions in online communities. Through social network analysis, we found that a relatively large number of help-seekers are supported by a small core group of helpers and suggest that it is critical to consider the high help-seeker-to-helpers ratio in this setting. In addition, we found two network triad motifs (M14 and M16) make up more than half of the network triads and that highly connected motifs were very sparse. The next step to pursue in this research is to examine the quality of discussion in a sample of the discussion data and examine if the motifs play a role in determining the quality of discussion. We believe that our approaches and findings can inform assessment practices in online learning conducted on MOOC and web-based course management systems.

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Collaborative learning in Facebook: Can argument structure facilitate academic opinion change?

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Abstract: Social networking services (SNS), such as Facebook, are an increasingly important platform for computer supported collaborative learning (CSCL). However, little is known about whether and how academic opinion change and argumentative knowledge construction (AKC) can be facilitated in SNS. Existing argumentation practice in informal SNS discussions typically lacks elaboration and argumentative quality. We investigate the potential benefits of argument structure provided through individual computer-supported argument diagramming to foster academically sound opinions in the context of Facebook. In a quasi-experimental lab study, we found evidence of academic opinion change along with correlations of opinion change with knowledge gains.

Argumentative Knowledge Construction in SNS

Social networking services (SNS), such as Facebook, Twitter, Google+ etc., are rapidly growing communication platforms. SNS provide easy platform-independent access and almost unrestricted interactivity for sharing ideas and opinions, and may therefore be conducive to argumentative knowledge construction (AKC; Weinberger & Fischer, 2006). AKC is the deliberate practice of elaborating learning material by constructing formally and semantically sound arguments with the goal of gaining argumentative and domain knowledge. Argument structure provided through individual argument diagramming is among the most prominent approaches to foster AKC in CSCL environments (Scheuer et al, 2010). However, there is little known about the extent these approaches can be applied to learning in SNS (McLoughin, & Lee, 2010; Tsovaltzi et al, 2012).

Current argumentation practice in informal SNS discussions lacks argumentative quality. Elaboration, evidence testing, and the evaluation of new knowledge are rare (Kanuka, & Anderson, 1998). This may not be surprising, since SNS were created for interactions at the personal level with users typically airing private opinions. However, *academic opinions*, i.e. opinions about academic and school subject matters are also shared, and potentially formed, through SNS (Roblyer, McDaniel, Webb, Herman, & Witty, 2010). Existing studies show that purposeful use of social media can support information sharing, communication and collaboration (Dabner, 2011), as well as learning (Laru, Näykki, & Järvelä, 2011). Yet, there is little systematic research on the educational potential of SNS for academic opinion change or formation, and the facilitation of learning.

Research results learning suggest that argumentative elaboration can promote individual knowledge construction, and can greatly benefit from additional support through scripting, i.e. socio-cognitive structures that specify what learners are to do in collaborative learning scenarios (e.g. Baker & Lund, 1997; Weinberger, Stegmann & Fischer, 2010). Learners, for instance, can be prompted to provide support or counterarguments for their claims. This can help them elaborate the task, gain argumentative knowledge, understand multiple perspectives, and promote knowledge convergence (Weinberger et al., 2010). An alternative way to script learners is to let them first work on a task individually and then compare and combine their individual solutions (e.g., Weinberger, 2011; Asterhan & Schwarz, 2007). Such approaches may prevent process losses of simultaneously following diverse instructions, also characterized as over-scripting (Dillenbourg, 2002), which can hinder AKC. Moreover, learners in online discussions often dismiss conflicting opinions and inconsistencies rather than try to resolve them. Raising awareness of opinion conflict is one way to foster critical argumentative elaboration during collaboration and take advantage of the dialogic potential of SNS (Bodemer, 2011).

In this paper, we investigate the potential benefits of argument structure provided through individual computer-supported argument diagramming for academic opinion change in Facebook and its influence on learning, compared to standard SNS discussions. We hypothesize that collaborators will resolve opinion conflicts productively by building on sound argumentation and attain higher knowledge gains after individual argument preparation as opposed to no individual preparation (Darnon et al, 2006). Our hypotheses are:

H1: Argument structure provided before SNS discussions will foster more academic opinion change than standard SNS discussions.

H2: Opinion change will correlate with knowledge gains.

Methods

To test our hypotheses, we conducted a quasi-experimental lab study. We compared two conditions: argument structure (ArgStr), which included individual construction of computer supported argument diagrams prior to the collaborative discussion in Facebook, vs. no argument structure (NoArgStr), which included collaborative discussion in Facebook only. The participants were randomly assigned to condition.

Forty (40) students at a German university – ten dyads per condition – took part in the study. Dyads were chosen to maximize conflict on ethical aspects of the discussion topic (behaviorism in the classroom) based on a questionnaire (see Section 2.2). Socio-demographic data, reported on an 1-5 Likert scale and analyzed with the MannWhitney-U-Test, showed no significant differences between conditions in frequency of SNS use, purpose of Facebook use (e.g., social contact and information exchange), ambiguity tolerance, interest or prior knowledge, self-assessed domain knowledge, and familiarity with SNS and computer.

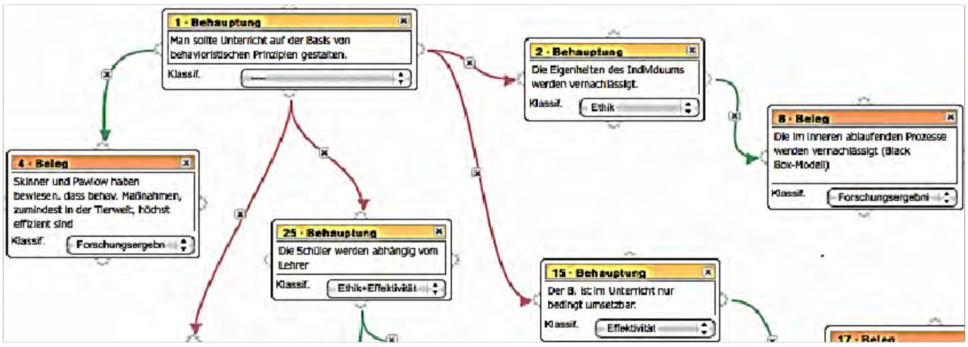

Figure 1. Abbreviated example of argument representation in *LASAD*

Due to privacy concerns, data collection for the experiment was done through specially created Facebook accounts. To maintain the effect of opinion conflict awareness, which is native in Facebook, we posted strong statements on behaviorism along two dimensions (*effectiveness* and *ethics* of behavioristic principles) and asked participants in dyads to use the "like" button to indicate agreement with these statements. An example statement on the ethical aspect is "The free will of a child must be facilitated at all costs."

Students in the argument structure condition used the web-based system, *LASAD,* to create individual argument diagrams (Loll, Pinkwart, Scheuer, & McLaren, 2012; see Fig. 1). Two types of boxes were available, one to represent "claims" and the other to represent "evidence". Students could choose from a dropdown menu whether (a) claims relate to the "effectiveness" or "ethics" of Behaviorism as a teaching method, and (b) whether evidence was based on "scientific results," "examples," or "everyday knowledge". Boxes could be related to one another through color-coded arrows, which indicated "support" (green arrows) or "opposition" (red arrows). The diagrams aimed at helping students to construct arguments for and against Behaviorism as a teaching method, contemplate the validity of arguments, as well as share and discuss the related evidence.

All students took an online pretest prior to the intervention in the Lab and a posttest. They also briefly read an essay on Behaviorism that could be used as reference during the intervention. The duration of the intervention was 55 minutes. NoArgStr used the entire time discussing on Facebook and trying to reach an agreement on the topic "*Should behavioristic principles be applied in the classroom?"* ArgStr used the first 25 minutes prior to the Facebook discussion to individually create an argument diagram with *LASAD* on the topic.

Opinion Conflict, Formation and Change

Opinion conflict, used to group dyads, was measured with a questionnaire in which participants had to state their agreement with statements on the effectiveness and ethical aspects of the principles of behaviorism for learning on a 5-point Likert scale. A statement on effectiveness, translated from the German original, is "Behaviorism can be applied with learning success on simple tasks", and on ethics, "It is potentially wrong to use negative reinforcement on kids." To analyze *opinion formation* independent of the direction of *opinion change* (that is, opinions becoming more or less favorable), we used a *t*-test of the absolute difference between the mean pre-statement score and the mean post-statement score of each participant.

Knowledge Test

Our knowledge test comprised twenty-four multiple-choice and two open questions ("Name some weak/strong points of behaviorism."), evaluated by two raters. The inter-rater-reliability was substantial for pre and posttest for the first question, *Cohen's* k_{pre} =.86; *Cohen's* k_{post} =.86, and moderate for the second question, *Cohen's* k_{pre} 51; *Cohen's* k_{post} =.44. To compare the knowledge scores we used the GLM Univariate procedure.

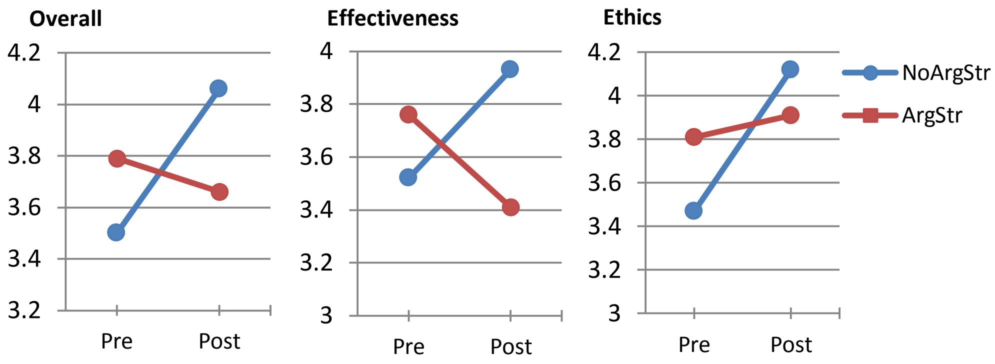

Figure 2. Opinion comparison: Overall, Effectiveness, Ethics

Results

Academic Opinion Formation and Change

Both conditions changed their *overall* opinion significantly, $t(39)=8.84$, $p<.001$, $d=1.40$, as well as on the two dimensions, *effectiveness,* $t(39)=8.10$, $p<.001$, $d=1.28$; *ethics,* $t(39)=9.04$, $p<.001$, $d=1.43$. With respect to *H1,* the influence of argument structuring on opinion change, the results showed that neither condition changed their opinions more than the other between pre- and posttest, either for the overall opinion, $F(1,38)=.09$, $p=.77$, or for the separate dimensions, *ethics*, $F(1,38)=.17$, $p=.68$, and *effectiveness*, $F(1,38)=.84$, $p=.36$. Since prior research suggests that cognitive conflict is predictive of collaborative learning in the context of social media (Kanuka &Anderson, 1998), we tested if the number of conflicts per statement would differ between conditions. Indeed, an ANOVA showed neither a significant difference between conditions on the mean number of conflicts per statement overall, $F(1,16)=.99$, $p=.33$, nor on ethical aspects vs. effectiveness separately, $F(1,16)=1.93$, $p=.17$.

To get a better idea of how these new opinions were formed between groups, we compared the direction of opinion change from pre- to posttest between groups (Figure 2). Prior to the learning intervention, ArgStr dyads judged Behaviorism as a teaching method more positively than NoArgStr: *overall*, $F(1,38)=6.80$, $p=.013$, $\eta_p^2=.15$; *ethics*, $F(1,18)=5.63$, $p=.023$, $\eta_p^2=.13$; and *effectiveness*, $F(1,18)=3.20$, $p=.08$, $\eta_p^2=.08$ (trend only). The attitude of the two conditions changed after the intervention giving interaction effects for all scores. NoArgStr dyads became less and ArgStr dyads more critical in their *overall* judgment, resulting in a strong interaction, $F(1,38)=9.70$, $p=.003$, $\eta_p^2=.20$. Both conditions evaluated ethical aspects of Behaviorism more favorably between pre- and posttest, $F(1,38)= 7.91$, $p=.008$, $\eta_p^2=.17$), but the ratings of the NoArgStr dyads increased more than those of the ArgStr dyads, producing a significant interaction effect, $F(1,38)=4.53$, $p=.04$, $\eta_p^2=.11$. An even stronger interaction effect can be observed between pre- and posttest on *effectiveness*, $F(1,38)= 10.79$, $p=.002$, $\eta_p^2=.20$ (Fig. 3). Here, the ratings of NoArgStr dyads changed in favor of Behaviorism's effectiveness, whereas the ratings of ArgStr dyads became less favorable. A plausible reason for the opinion change may be that conflict awareness helped partners in both conditions to transact on another's opinion. This active cognitive engagement with conflicting views may have destabilized their original opinions and caused changes that are depicted in the strong interactions.

Domain Knowledge Gains

The comparison of the conditions in the pretest showed a significant difference in the pretest for the percentage of correct answers, $F(1,38)=18.59$, $p<.001$, $\eta_p^2=.33$. Both conditions did significantly better on the posttest than the pretest, $F(1,38) = 87.55$, $p<.001$, $\eta_p^2=.70$. The knowledge gains of the two conditions did not differ, $F(1,38)=.73$, $p=.399$, $\eta_p^2=.02$.

The opinion formation and change reported in the previous section is particularly interesting as it may signify a potential for knowledge gain via a deeper processing of domain knowledge in SNS. This is one of the biggest promises of ACK and of co-construction of knowledge. To test this possibility, we calculated correlations between opinion change and knowledge gains. The correlation between *overall opinion change* of both conditions together and the *overall knowledge gains* just missed being significant, $r(40)=.31$, $p=.050$. Although this effect seems to confirm *H2*, a closer look shows that the correlation for both conditions together is probably due to the very high correlation found for NoArgStr alone, $r(20)=.54$, $p<.05$, but not for ArgStr.

Discussion

Despite the generally held opinion that Facebook is shallow and non-serious, we found evidence that it can be used for academic opinion formation and change when sufficiently supported. We theorized that argument structure as support for sound academic argumentation would favor academic opinion formation more than standard SNS discussions when opinion conflict is highlighted. This did not prove to be the case. Moreover, we could not establish a correlation between opinion change and knowledge gains for argument structure. On the contrary, we found highly significant correlations between opinion change and knowledge gains for the NoArgStr condition. A possible reason for these results could be the higher prior knowledge of the NoArgStr condition, which may benefit opinion change in the context of AKC (Darnon et al., 2006). However, it is worth investigating whether opinion conflict awareness is a stronger predictor of academic opinion change and how argument support exactly interacts with such awareness.

Given the open and social character of SNS and the possibility to acquire new, unpredictable knowledge and skills, such as openness to opinion change, assessment of learning in SNS needs to be redefined. Traditional learning tests based on factual knowledge or problem solving skills do not capture the power of SNS and remaining faithful to them can limit the effectiveness and restrict the potential of SNS as learning tools.

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Leveling the Playing Field: Making Multi-level Evolutionary Processes Accessible through Participatory Simulations

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Abstract: Recent research in Learning Sciences has drawn attention to the affordances of enabling students to learn about scientific phenomena through a complex systems lens. In this study, we adopt a complex systems perspective in helping students learn about a multi-level phenomenon, artificial selection, by using an agent-based participatory simulation – Bird Breeder. Our goal is to investigate how design revisions to the activity in the form of 1.) Explicit representations of students' shared experiences, 2.) Access to an underlying third level of alleles, and 3.) Transparent rules of interaction facilitated abstraction of population-level trends in terms of change over time. We draw on data from two iterations of an agent-based modeling curriculum for evolution as part of a design-based research study in three tenth grade biology classes in the mid-west. The findings hold implications for the design of participatory simulations in general, and ways to support meaningful learning about complex multi-level phenomena in particular.

Literature Review

The study of complex systems is quickly becoming a new strand of literacy (e.g., Ben-Zvi Assaraf & Orion, 2005; Jacobson & Wilensky, 2006) because it offers new explanatory frameworks and methodologies that are increasingly being adopted in scientific and professional environments. We consider a complex system to be an emergent system in which population-level trends emerge from individual-level mechanisms.

Biology is replete with instances of complex systems in which phenomena can best be understood by grappling with relationships between levels in the system. Evolution, which is central to the study of biological sciences, is one such complex emergent phenomenon that involves change at multiple levels of the population such as the level of alleles, organisms and species. While most work on student learning about evolutionary processes focuses on an understanding of connections between two levels, we try to support student reasoning about a third underlying level, the level of alleles or genes of individuals in the population.

We do this work using agent-based models (ABM). In an ABM, individuals in a system are assigned rules for interaction with other individuals or the environment. The execution of these rules, over time, results in distinct, often surprising, trends at the aggregate level. This delineation renders ABMs as an epistemological match for learning about evolution for a couple of reasons. First, they provide accessible entry points for learners who have cognitive resources at the agent-level (e.g., Papert, 1980) that can be leveraged to build conceptual links between agent-level behaviors and aggregate-level trends (e.g., Wilensky & Reisman, 2006). Second, ABMs alleviate a difficulty associated with learning about evolution in particular, and complex systems in general called *slippage between levels* (Wilensky & Resnick, 1999d).

Most of the work using ABMs to learn about evolution has involved students exploring models of evolutionary processes as an *observer* of the system (e.g., Wilensky & Centola, 2007; Wagh & Wilensky, 2012a). In this paper, we examine the use of ABMs in which students are *participants* in the system. This is done using a particular form of a computer-supported collaborative learning environment called a *participatory simulation.* The experience of engaging in a participatory simulation can be characterized by Ackermann's (1996) metaphor of "diving-in" and "stepping-out" to develop a deep understanding of a system (Colella, 2000). "Diving in" entails taking the perspective of an agent in the system, by enacting the role of the agent from within the system, while "stepping-out" entails projecting and objectifying one's personal experience in order to deeply understand it (Ackermann, 1996). Going back and forth between diving into the system, and stepping out, enables learners to increasingly appropriate the relationship between emergent aggregate-level change in the system and the agent-level mechanisms that drive the change (Wilensky & Stroup, 1999a).

In this paper, we describe how students synthesize population-level trends in stepping out of a part-sim, Bird Breeders, which is part of a curriculum on evolution (Novak & Wilensky, 2010). Specifically, we examine how design revisions to the activity supported abstracting population-level outcomes of the part-sim. Prior work has described how diving into this part-sim enabled students to spontaneously adopt, and later project and objectify the mechanisms underlying the system (Wagh & Wilensky, 2012).

Bird Breeders Participatory Simulation

The Bird Breeders activity was developed in the HubNet module (Wilensky & Stroup, 1999a) of NetLogo (Wilensky, 1999b). Working in groups of four, each student assumes the role of a bird breeder and is randomly assigned three or four birds at the start of the simulation. These birds differ from each other with respect to four traits: the color of their crest, tail, breast and wings. The group's goal is to breed birds that are homozygous recessive for the four traits.

Methods

This study was conducted in the context of a two-week long implementation of an evolution curriculum as part of a design-based research study (e.g., Brown, 1992; Collins, 1990). In this paper, we report on data from two iterations of implementations each conducted in three tenth grade biology classes in a mid-western town in the United States. The same teacher led this implementation in both iterations.

Here, we specifically report on data from the Bird Breeders participatory simulation of artificial selection. In both years, the students spent one class period working on the Bird Breeders model. Note that in this paper, we focus on what students explicitly reported to have understood about the mechanisms and outcomes of selective breeding. In general, when characterizing student responses in both years, a dimension that was important to us was a description of outcomes in terms of *populations changing over time.* This is because as the first activity in a curriculum on evolution, we wanted it to foster an understanding of artificial selection as changing populations over time, so that this understanding could be leveraged through the rest of the curriculum.

Findings from Year 1

In the first year, we analyzed 18 student responses to examine student descriptions of what they had learned about outcomes of selective breeding. Though student responses varied, ten out of eighteen student responses involved static descriptions of specific birds in the part-sim (e.g., "red wings, blue feathers, grey belly") or a seemingly random response such as "3 results would be color of the fur, the ear shape, and the length of the hair". Though these responses were not "incorrect", we hypothesized that a lack of attention to how a population changes over time would make it difficult for these students to leverage their experience of having engaged in this activity to understand other evolutionary processes later in the curriculum.

Only eight out of eighteen student responses focused on a change in the bird population over time. This led us to revisit the design of the activity to reconsider some of our design decisions. We had two goals: 1.) To support more students in being able to describe the outcomes of selective breeding in terms of populations changing over time, and 2.) To encourage students to notice an underlying third level, that of alleles and genes, and examine how it was changing over time as well.

Design Revisions based on Findings from Year 1

In re-considering our design decisions, we wanted to foreground how the population had changed over time, both at the level of individual phenotypes, and the underlying gene pool. These dual goals led to three main design revisions, each of which will be described in detail here:

1. Explicit aggregate-level representations of students' shared experiences

In looking back at the design of the activity, we noticed two sources of difficulty: one, the data students collected in the activity did not help draw their attention to how the population had changed over time. For instance, groups collected data on the number of birds they had to release into the wild, and the number of eggs the group had laid. The underlying rationale for collecting this data was to facilitate a comparison of effectiveness of different strategies that groups had adopted to breed the goal birds. However, the iteration in Year 1 made it clear to us that though this goal of comparing strategies was important, it was more important to draw students' attention to changing trends in the population. Perhaps more problematically, the original Bird breeders' model did not include plot/s to track the changing population. In the absence of an aggregate-level representation to record change in population, the students did not have a reference point to step out and reflect on the outcome of their shared experiences and reason about population-level trends.

To address these issues, we decided to include plots of changing frequencies of variations (phenotypes) and alleles in the population. In addition, at the end of the activity, students were asked to record the plots, instead of number of birds and eggs. The goal was to draw their attention to how the population had changed over time.

2. Giving access to an underlying third level of alleles

One group's use of the "prohibited" View-genotype feature led us to think more carefully about the affordances of this feature. In the original version of this model, turning on the View-genotype switch made the genotype information of all birds available at once, and left it available until the feature was turned off. This unlimited access to the genotypes of all birds made the task less challenging.

We decided that a design fix would include a feature that enabled students to access the genotype of birds a fixed number of times. This led to the development of a new feature called "DNA Sequencer". With this feature, each player could pick a certain bird to sequence its DNA, and get access to the genotype of that bird for the rest of the simulation. However, each student could do this for only a fixed number of birds, determined by a slider in the simulation. Providing groups with limited access to genotypes through the DNA sequencer ensured that the challenging nature of the task was not compromised.

3. Transparent rules of interaction

Our class observations from Year 1 suggested that some groups had difficulty learning the rules for participating in the simulation. This lack of clarity often frustrated students who unintentionally released prized birds or repeatedly attempted breeding birds without success. It is perhaps because of this lack of transparency of rules that all groups did not succeed in breeding goal birds in Year 1.

In order to rectify this issue, we decided to add visual cues to the simulation to make rules for interaction transparent. First, a bird's readiness to breed is indicated by a heart that appears next to the bird. A little arrow next to the bird denotes that it needs to be taken back to its cage before it can be used for breeding again. Finally, the area in which birds can be released into the wild is represented by green grass. These visual cues were intended to make participation in the simulation smooth and effortless, so that groups could focus on the activity itself.

4. Breeding more goal birds

As previously described, this activity is atypical of participatory simulations because of its small scale. Though classic part-sims include the entire class, the Bird Breeders model included groups of four students. This small-scale might have made it difficult for students to notice population-level trends when breeding only three homozygous recessive goal birds. Hence, we revised the activity so the goal for each group would be to breed three *pairs* of goal birds, rather than three birds to make the trend more noticeable.

Findings from Year 2

In Year 2, we implemented the revised version of the Bird Breeders part-sim. Here we report data from 11 responses of 22 students working in pairs.

In the class discussion, the students decided to divide up their responses about outcomes into three categories: "Big differences between individuals at the beginning and the end", "Changes gene pool", and "Offspring with desirable traits". In developing our own categories to sort student responses, we realized that our categories very closely aligned with the ones that the students had developed. Hence, we decided to use student-generated categories to describe the findings.

1. Big differences between individuals at the beginning and the end

Responses in this category described how the population of birds at the start of the simulation looked different from birds at the end of the simulation. For instance, one response in this category read "Depending on how similar the parents are, the offspring could var[y] quite a bit, the final generation had introduced new variations of traits relative to the first generations or their ancestors".

This pair described an outcome in two ways: one, the similarity in traits of the parents influences what the offspring will look like, and two, the final generation manifested different variations and looked different overall from its ancestors.

2. Changes gene pool

Responses categorized here referred to change in the gene pool over time. For example, one pair wrote, "When you partake in selective breeding, you are altering the gene pool. The frequency of traits change. Less popular traits become more common if they're desirable".

This pair reasoned that engaging in selective breeding involves changing the gene pool of a population in terms of frequency of traits. Even infrequent traits can become more common if they're desired.

3. Offspring with desired traits

The responses in this category indicated an understanding that through selective breeding, some traits would be removed from the population, while others would be retained. By way of example, one of the responses read "Outcomes of selective breeding are that the "bad" traits are gone and the "good" traits are still remaining. You could see this when we breed the bird."

These findings suggest that overall, in Year 2, student descriptions of outcomes of selective breeding included an emphasis on populations changing over time, and also represented multiple levels of the population. Moreover, we did not see any instances of descriptions from categories 1 and 2 from Year 1.

Discussion & Implications

At the start of this paper, we framed the experience of a participatory simulation in terms of "diving in" and "stepping out" to develop a deep understanding (Ackermann, 1996). The data we have described in this paper facilitates a closer examination of students stepping out from the participatory simulation in pairs to reflect on what they learned. The findings of this study suggest that our three design principles supported productive reflections on stepping out: 1.) Providing explicit representations of students' shared experiences, 2.) Providing access to an underlying third level of alleles, and 3.) Supporting transparent rules of interaction.

Conclusion

In this study, we investigated how specific design decisions for a part-sim designed to support learning about selective breeding in small groups, influenced learning at the level of the individual, and the level of pairs within each group. Prior work has found that this particular part-sim did support group learning about mechanisms of artificial selection as students were engaged in the activity (Wagh & Wilensky, 2012b). However, this work also found that at the individual level, students had trouble abstracting trends from the activity. This led to redesigning the group experience by in three ways: providing each group with concrete records of their shared experiences in the activity in the form of plots, providing each group with access to more information such as information about genotypes, and finally, making rules transparent to ease the group experience of using the part-sim. In reporting data from the second iteration, we analyzed learning at two levels: first, briefly at the level of the entire class by looking at the three big categories of outcomes that they abstracted from their experience, and second, at the level of pairs from each group. In future work, we would like to analyze data from whole-class discussions to closely investigate sense-making at the level of the entire class.

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Examining High School Students' Learning from Collaborative Projects Related to Alternative Energy

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Abstract: Constructivist learning theory is used to examine students' individual understandings from a collaborative science-writing project on alternative energies supported by Web 2.0 technologies. We examine how high school chemistry students (n=30) make sense of alternative energy constructs through analyzing changes in pre- and post-intervention concept maps. Through statistical and structural analysis of their concept maps, we investigate changes in the students' understandings about alternative energy. Our findings suggest that students increased their knowledge about alternative energies at different levels, reflecting both surface and deep learning of related environmental education concepts, as well as creating strong connections between concepts related to safety, costs, and health for different types of alternative energy. In addition, student elaboration increased for all energy types, suggesting that the jigsaw pedagogy was successful in improving individual understandings.

Introduction

Learning sciences research has taken a fruitful line of work to provide students engaging in collaborative projects with technologies to support their thinking and learning (Stahl, Koschmann, Suthers, 2006). Our work is situated in the effort to support learners with educational technologies as they participate in science practices with a goal of understanding how students use Web 2.0 tools as they collaborate to make sense of complex scientific topics. However, within school settings, the collective learning that occurs in classrooms is still often measured on an individual basis (Sawyer, 2006). Therefore, although knowledge is constructed through negotiation of meaning within the group, the individual's understandings are of great importance. For this paper, we analyze how a collaborative unit on in two high school classrooms that uses wikis, social book marking, and podcasts can support individuals' meaning making about alternative energies.

Conceptual Framework

Our work adopts a constructivist approach to learning: learning is the individual's process of building knowledge and skills based on their social interactions (Pena-Shaf & Nicholls, 2004; Sharples, Taylor, & Vavoula, 2005). In accordance with Vygotsky (1978), we view the process of construction of knowledge as containing both individual and social practices (Scardamalia & Bereiter, 2006). This constructivist approach connects individual learning to the negotiation and understandings of the meanings within the group environment (Jonassen, Davidson, Collins, Campbell, & Bannan Haag, 1995).

Our focus is on understanding learners' outcomes: the ways in which individuals made meaning from the group learning experience (Sawyer, 2006). To understand student sense making about alternative energies, we employed qualitative and quantitative analyses of pre- and post-concept maps (Hay, Wells, & Kinchin, 2008). Students used concept maps to place their ideas about topics into nodes, and then the students were asked to connect nodes using lines (annotated with linking terms) showing relationships between the concepts (Novak, 1990). Researchers (Hay, Wells, & Kinchin; Novak & Canas, 2008) have shown that repeated use of concept mapping about the same topic provides the researcher data about prior knowledge; learners are integrating new concepts into prior understandings, and making evident changes in connections that students see about concepts through changes in the map structures (Hay, 2007; Hay, Kinchin, & Lygo-Baker, 2008). Through analyzing how students arrange the nodes into structures such as spoke, chain, and network representations (Kinchin, Hay, & Adams, 2000), students make visible their understanding of the concepts and provide insight into how they made sense of the newly learned materials (Jonassen, Reeves, Hong, Harvey, & Peters, 1997). Categories commonly used to describe the meaning making observed on concept maps (Hay, Kinchin, & Lygo-Baker) include non-learning, surface learning, and deep learning (See Table 1).

In this analysis, we answer the question: How does the breadth and depth of high school students' individual understandings about alternative energy resources change following their participation in an online collaborative learning project in a high school chemistry class? While we conducted both qualitative and quantitative analyses, only the quantitative results related to meaning making are shared due to space limitations.

Table 1: Levels of learning demonstrated on concept maps (based on Hay, Kinchin, & Lygo-Baker, 2008)

Learning	Changes on concept map	Interpretation

Non-learning	No changes to the structure occur.	No new learning - prior knowledge is repeated.
Surface learning	Some concept nodes can be eliminated. New concept nodes are added but not connected or linked to the prior knowledge concepts, or chains of concepts are formed.	Students have adopted new concepts but have not connected these to prior knowledge. Elaboration of concepts via simple chains shows sequentially structured information has been added. Considered rote learning.
Deep learning	Concept nodes are added to the map and linked to the prior concept nodes and/or each other. This can occur as elaborated spokes or networks.	Integration of new concepts as well as significant elaboration of original concepts with added nodes or levels of hierarchy. Connections across concepts or additional links are created. Considered meaningful learning.

Alternative energy unit

This study occurred in two rural high school chemistry classrooms using 1 to 1 laptop computing. Students (n=30) completed a Web 2.0 technology project that focused on argumentation as a means of acquiring content knowledge (Zohar & Nemet, 2002), related to the strengths and weakness of forms of alternative energies. The students, aged 15 to 17, developed an online wiki resource for each other about alternative energy. Learners used the wiki pages to create persuasive podcasts for a fictitious scenario: to sway the town council to vote for an alternative energy plant to be built in their local community. Alternative energies covered in the unit were biomass, solar, wind, geothermal, hydroelectric, and nuclear power. Jigsaw pedagogy (Aronson, 1978; Brown, 1994) was used: the students were placed into small groups to each create a wiki page about one alternative energy resource; podcasts were created for a second resource. All students were responsible for understanding information about every type of energy resource. Computer-supported collaborative learning occurred within this unit both asynchronously across two classrooms and synchronously within the classrooms.

Before and after the unit, concept maps were created by each individual student using the same focusing question (Novak & Canas, 2007): "What do you know about different types of alternative energy resources that would allow you to make an informed decision about their use in your community?" These maps were used as an assessment of individual understanding and meaning making about alternative energies.

Methodology

We conducted a three-week video-based case study focused on the role of Web 2.0 technologies in supporting high school students' engagement in argumentation. In this paper, we present the statistical and structure analyses from students' pre- and post-concept maps from two high school chemistry classes (n=30). These analyses allow for comparison of prior knowledge and new knowledge as well as the meaning making that occurred (or did not occur) demonstrated by changes in concept maps (Hay, Kinchin, Lygo-Baker, 2008; Novak & Canas, 2008). Data collected for the project included: 1) video-podcasts, 2) social bookmarking records, 3) student constructed wiki pages, 4) questionnaires, 5) interviews, 6) pre- and post-concept maps, and 7) 3-weeks of daily video-recordings. Our strategy provides reliability for the overall study through triangulation of data.

For this analysis, we focus on individual meaning making through changes on the pre- and post-intervention concept maps. To address reliability of the coding, a key was constructed with examples and definitions (see Table 2). The first author coded all concept maps. An independent researcher coded approximately 20% of the maps and discussed differences until consensus was reached. We conducted two analyses: a statistical analysis of the pre- and post-concept map counts and a qualitative analysis of structure. The concept maps were coded for organization: number of nodes, hierarchy, connections, annotations, and branches. During the construction of the wiki pages, students chose topics that they felt were central to understanding how alternative energy plants would impact their community; these were used as coding categories as well: types of energy; safety of energy; cost to community and/or individuals; impacts to the geographic region and community space; and impacts to community and human health (see Figure 1 for a sample coded map). In addition, we also analyzed changes in connection structures (spoke, chain, network) within each pair of maps (Hay, Kinchin, Lygo-Baker, 2008); each map was evaluated for the level of learning (non, surface, or deep) and was assigned a value (1, 2, 3). The counts for each coding category were entered into Minitab statistical software and analyzed using a paired T-Test.

Table 2: Coding/counting scheme for several categories used in analysis of the concept maps.

Code	Definitions
Nodes	Number of nodes created; this is a proxy for the number of ideas the student understands.
Levels	Hierarchy of the map – the number of levels of nodes (where the first level is linked to the center node); this is a proxy for the student's connections and conceptual integration.

Types	Types of alternative energy resources that are listed. Types studied in this unit are hydroelectric, wind, solar, nuclear, biomass, and geothermal.

Findings and Results

Of the coding categories, "safety", "geography/space", "costs", and "health" were found to have significant changes at a $p < 0.05$ level in the post-intervention map (See Table 3). Students used these organizing topics from the wiki, as well as specific related details about them, in their maps showing that these ideas were incorporated into their knowledge structure. This indicates an increase in student understanding of the social and scientific issues involved in communities adopting alternative energies. The structural differences in the maps indicate changes in the individual student's meaning making (Hay, Kinchin, Lygo-Baker, 2008). Only 4 map sets were identified as non-learning based on lack of changes in the structure; all other maps showed evidence of representation changes that indicate either surface or deep learning through elaboration of concepts and complexity of the new map structure. Although few linking words or connections across maps were observed, the number of ideas (nodes) added in complex chain and spoke structures provided evidence of change in level of learning. A paired T-test was used to examine the assigned scores for changes in level of learning, which was significant at a $p < 0.05$ level (Table 3).

Figure 1: Molly's coded pre- and post-concept maps

Statistical analysis indicates that student knowledge of alternative energy concepts has changed in breadth and depth over the course of this unit. The number of nodes, or ideas, and hierarchy of levels increased significantly; increases in these factors show significant elaboration within the post-intervention map, indicating that learning has occurred (Hay, 2007; Novak & Canas, 2008). The number of types of energy that were identified by students on their post-maps increased significantly from a mean of 3.367 to 5.033 types. In addition to the structural changes in the maps, ideas (nodes) added show that the number and type of terms students' used to describe alternative energies increased on their post-concept map. These changes in breadth of learning through the greater number of energies that students chose to include on the map indicate increased learning at a deeper level. Through student display of content related to all types of energy on the maps, not only the topics assigned to their groups, our analysis indicates the jigsaw pedagogy was successful in providing supporting meaningful learning about all topics.

Table 3: Coding categories with differences in pre- and post-concept maps at a statistically significant level

Code	Pre-intervention		Post-intervention		Significance p-value
	Mean	St. Dev.	Mean	St. Dev.	
Node quantity	9.27	4.93	18.47	7.93	p = 0.000
Levels of node connections	1.967	0.615	2.500	0.820	p = 0.003
Energy types	3.367	1.159	5.033	1.542	p = 0.000
Safety of energies	0.567	0.971	1.333	1.446	p = 0.011
Costs of energies	0.800	1.186	2.867	1.871	p = 0.000
Geography/space impacts	0.733	1.596	1.667	2.187	p = 0.019
Health impacts from of energies	0.133	0.434	2.100	2.155	p = 0.000
Changes in learning via structure	1.400	0.563	2.533	0.730	p = 0.000

Conclusion

With a focus on collaborative work in classrooms (Sawyer, 2006), understanding how individuals make sense of group knowledge building experiences is an important line of research. We showed that concept maps are a tool that can assist researchers and educators in this area. Students used the pre- and post-intervention concept maps as tools to make their individual understandings of alternative energy visible. Analysis of the map structures and alignment with levels of learning (Hay, Kinchin, Lygo-Baker, 2008) allowed us to understand how students were creating connections to prior knowledge and individually making sense of the group learning experience. Future research can examine how these structural changes can assist in differentiating instruction within the collaborative projects to better support individual learning.

We investigated student meaning making from participation in a collaborative wiki and podcast project through analyses of pre- and post-intervention concept maps. The statistical analysis indicates that students learned about all types of energy in this project. They increased the breadth (number of ideas about alternative energies) and the depth of understanding (expanding the ideas they had by connecting and reorganizing their concepts) at a statistically significant level, indicating that individual students adopted content from both the energy topics for which their groups specifically built resources as well as for those alternative energies that the others in the class created within the jigsaw pedagogy (Aronson, 1978). Research can focus on design principles to support making connections between segments of projects in which students are not directly involved.

Also, we found that using the student-created artifacts (i.e., the wikis) to develop the qualitative coding scheme for the maps allowed us to understand the development of ideas from the social to the individual level. Future research can go more in-depth into the qualitative analysis of concept maps to assess the nuanced details of individual meaning constructed through collaborative projects, connecting ideas from the in-classroom discourse and computer supported discourse.

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Finding Evidence of Metacognition through Content Analysis of an ePortfolio Community: Beyond Text, Across New Media

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Abstract: Finding evidence of how metacognition is demonstrated in educational ePortfolios is often limited to written artifact analysis and ignores new media such as images, video, links, and navigation schema. This study seeks to begin to fill this gap through a qualitative content analysis of 30 learners' ePortfolios developed in a networked ePortfolio community. We found evidence of learners' metacognition in their choices, integration, and organization of new media content in the ePortfolio. We propose that intentional analysis of learners' choices and arrangement of new media can help educators and researchers find additional evidence of metacognition beyond text within digital learning interventions like ePortfolio communities.

Introduction

Metacognition is a learner's ability to reflect upon and monitor learning activities and strategies, a key factor in successful learning transfer (Bransford, Brown, & Cocking, 2000). Researchers assert that ePortfolio development is valuable for metacognitive development because it helps learners track and reflect on their learning (Blackburn & Hakel, 2006). Evidence of metacognition in ePortfolios is based on analysis of text-based artifacts and reports (e.g., Meyer et al., 2010), but these analyses do not take into account learners' inclusion of new media.

Through a qualitative content analysis of new media in 30 learners' ePortfolios developed in a college-level writing course, we found patterns across learners' choices, integration, and organization of new media ePortfolio content such as images, videos, navigation schema, and embedded forms. These elements reflected metacognition characteristics including situating oneself in a learning community, becoming a writer and navigating the learning process, and valuing writing and learning more generally. We argue that how learners choose to organize their online environments, their choice of new media content, and how they present it can provide evidence of learners' metacognition. Thus, it is important that researchers consider methods for identifying and assessing learning in digital learning environments that take these new ways of demonstrating learning and metacognition into account.

Review of Literature

Metacognition, or knowledge about one's own cognitive processes, is a core learning outcome in liberal education (Ottenhoff, 2011). Learners' ability to understand and analyze themselves as learners and their learning processes leads to strengthened transfer of knowledge and skills (Bransford et al., 2000). Akyol and Garrison (2011) developed a metacognition construct that includes three metacognition components: knowledge of, monitoring, and regulation of cognition (see subset of construct in Table 1 below). For example, when developing writing skills in a writing course, a learner's awareness and understanding of key self-regulating processes like planning, drafting, and revising is a form of metacognition (Perry, 1998). While evidence of metacognition is often elusive in educational situations, researchers have used a variety of methods to identify metacognition in written artifacts and transcripts (Lai, 2011), but the degree to which these accurately assess metacognition is debated (e.g., Pintrich et al., 2000).

Table 1. A subset of Akyol and Garrison's (2011) Metacognition Construct

Knowledge of Cognition	Monitoring of Cognition	Regulation of Cognition
Pre-Task Reflection • Knowledge of factors that influence inquiry and thinking • Knowledge of self as a learner	Reflection on Action • Asking questions for confirmation of understanding • Commenting about self's and others' understanding	Reflection in Action • Procedural; planning • Setting goals • Providing/asking for support

Technologies that facilitate development of, critical reflection upon, and representations of learning have developed rapidly in terms of their scope and reach. A digital learning environment that researchers claim facilitates metacognition is the educational electronic portfolio ("ePortfolio"). ePortfolios are championed as tools for learners to analyze, synthesize, and share their experiences inside and outside of school in a way that print-based portfolios could not. A review of the literature on ePortfolios shows that researchers have not analyzed new media specifically for evidence of metacognition; however, new media researchers suggest that an analysis of learners' multimodal artifacts offers insights into learners' identity, understanding, and creative processes (e.g. Halverson et al, 2012).

In previous interviews with learners using ePortfolios, we found that learners had engaged in metacognitive practices (Wozniak & Zagal, 2012). However, we were unsure if there would be evidence of those practices in the ePortfolio itself. In addition, if we were to find such evidence, what form it would take? Our main research question for the current study is: What evidence of metacognition is present in an ePortfolio community? And, considering previous research in this area has focused mainly on learners' written artifacts, we intentionally asked: What evidence of metacognition exists specifically in new media ePortfolio content?

Method

We conducted a qualitative content analysis of 30 learners' ePortfolios developed in a college-level introductory writing course over one term, intentionally seeking evidence of metacognition. The writing course focused on strategies and tools for planning and developing a writing process, researching and integrating sources, organizing ideas into essays that follow general academic conventions, and demonstrating writing proficiency with an ePortfolio. To build their ePortfolios, learners used software with a WYSIWYG page editor with social networking features such as commenting, tagging, and directory search. The instructors directed learners to include course assignments, such as their writing plans and essay drafts, but also welcomed other artifacts and elements and encouraged them to explore all the software features. The instructors gave no requirements for how to organize and label the ePortfolio contents or types of new media elements.

After the course, we conducted a content analysis of 30 learners' ePortfolios (with their consent) to search for evidence of metacognition. Content analysis offers an opportunity to analyze static documentation (usually transcripts) to evaluate deep learning, cognitive skills, and metacognition (e.g., Newman et al, 1995). To look for evidence beyond written artifacts, we conducted a descriptive page-by-page inventory, somewhat like an annotated sitemap, of all new media ePortfolio contents including text, image, embedded documents, forms, video, links, commentary, and organization schema. We then used process coding (Saldana, 2009) to code for places in these descriptive site maps where learners demonstrated metacognition in the form of self-regulation, self-monitoring, and reflections on their learning processes in the writing course. Process coding, a method of coding actions (codes are typically gerunds ending in "–ing"), was useful here because metacognition is often defined with action-based criteria. Our codebook included process codes such as "planning," "demonstrating process," "welcoming comments," and "inviting community." Thus, if a learner chose to embed a contact form on a particular page within the portfolio, we coded this as "welcoming questions and comments" and "inviting community." We analyzed those process codes to identify patterns that suggested manifestations of metacognition in the ePortfolio community.

Findings

Our process codes analysis showed higher-level patterns of behavior in the ePortfolio with the following metacognition characteristics: (1) how the learners *situate* themselves in a learning community, (2) how the learners *understand themselves as learners/writers* and *navigate* the learning process, and (3) what they *value* with regard to learning. Specifically, our process coding revealed higher-level patterns of "situating," "becoming", and "valuing".

A. Situating

All 30 learners chose to include a Welcome page or About Me page as the ePortfolio landing page. Some learners only included text-based signifiers of identity, such as a general greeting, name, age, location, job, and explanation of the purpose of the portfolio. However, other learners also chose to include images, videos, and links that reflected the topic of the course (writing) or some aspect of the learner's identity (see Figure 1). Many learners also added a preset "Contact Me" form or asked visitors to use the default Comment form in their Welcome or About Me page, suggesting that a form of contact should not be an afterthought, but a first consideration for the audience. One learner stated in his portfolio, "As a techie, [this portfolio] really allows me to have fun in creating it but also as a place to see my work in an open space where others can comment as well for great feedback." Another learner chose to make a commenter's message public, that of her teacher, and points it out to her audience: "I am also including feedback from my professor for the essay drafts to show the progression of my writing."

Figure 1. Images and videos that reflect the course topic and learners' identities as learners and professionals.

By choosing to include these elements in their "Welcome" and "About Me" pages, learners situated themselves in the learning community in non-textual ways. Instructors did not require learners to include a Welcome/About Me page, integrate new media elements reflecting their identities as learners, or invite the community to connect with them and join them in discussion about the ePortfolio contents. We believe learners' intentionally chose to include new media elements in this way because not only are they conventional elements for other digital representations of self such as personal homepages and social media, but also because these were common elements they identified in other learners' ePortfolios in the system through the directory. Yet, their unique choices of new media content for these pages gave them an opportunity to show others what they valued and could contribute, and what they wanted from the community in return. This is a metacognitive characteristic that shows learners intentionally and independently thinking about the discipline of writing, building their ethos, and recognizing what it takes to enter and situate oneself in the larger learning community.

B. Becoming

How a learner decided to organize and label new media in the ePortfolio was evidence for how they were "becoming" writers and reveals, symbolically, how they "navigate" their own learning. The type and organization of the ePortfolio menu items reflected their process as writers and their intentions to move from novices ("First Drafts" or "Start of the Term") to experts ("Final Drafts" or "End of the Term"). Even if learners were reiterating the order of assignments in the course syllabus, or following the structure they saw in another portfolio, their deliberate choice to "re-mix" the labels and organization of the pages in this way demonstrates metacognition because they recognize and take ownership of strategies inherent and important in the expert writing process.

Additional evidence of learners' move from novice to expert, a process of "becoming," was seen in their choices and arrangement of new media in the context of their early assignments compared to their final assignments. Learners included quotes, images and videos about writing from perceived authorities (authors, scholars) with early assignments. In final assignments, they generated their own quotes or theories on writing, as "emerging authorities," with supporting images and video (see Figure 2). For example, on her Welcome page, a learner quoted a professional writer and, on her "Goals" page, she linked to a video, "Writers on Writing". Later, she writes in her final reflection, "I was able to reflect on my ability to target my audience, identify my writing task, and effectively reach the goal of my writing. I then concluded that I am a writer." While some of these reflections were assigned, learners' decision to post and place them in specific locations within the portfolio demonstrates their recognition of self-monitoring in learning as well as a community that values this type of reflective practice or reflection-in-action.

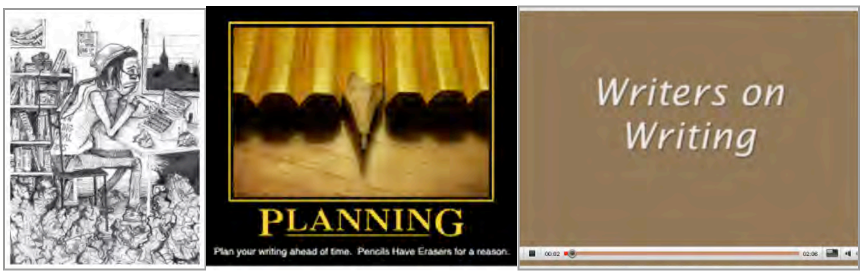

Figure 2. Images and videos show learners' thoughts on being a writer and aspects of the writing process

C. Valuing

Learners signaled what they valued in their learning experiences in the format and topics of the essay drafts they posted in the ePortfolio. In more than half of ePortfolios, learners cut and pasted their drafts from Microsoft Word docs, did not change the format (including the MLA paper heading of name, date, instructor at the top), and only sometimes provided context for how a particular draft or set of drafts made a contribution to their learning or the learning community. We took this lack of "re-mediation" as a sign that learners were appealing to the requirements for the course. They completed tasks that mattered to the teacher with little focus on connecting or building a community through representations of their identities and experiences as we saw in the About Me/Welcome pages.

On the other hand, after exploring other elements of the learners' portfolios, it became apparent that the topics of the essay drafts often reflected something related to the learner's interests and, in a few cases, connected to signifiers of identity in their About Me and Welcome pages. Many of the essay assignments in the course encouraged learners to write about something that interests them or with which they had experience, and a few learners did make these connections explicit for the community in the digital environment of the ePortfolio. They did this by adding reflective statements at the top of pages that connected one page to the next, removing print-based formatting elements like headings, embedding links to information on the web when relevant in the body of their writing, and embedding images that support the content of their essays, all without guidance from the instructor.

Discussion

This content analysis shows how learners revealed, beyond text and across new media, their situation in a learning community, learning process, and understanding and value of a discipline (writing, writers). Analysis beyond textual content—specifically an inventory, coding, and thematic analysis of learners' choices and arrangement of new media—can help educators and researchers find additional evidence of metacognition within learning environments like ePortfolio communities. For example, those seeking evidence of metacognition in learner-controlled environments such as course wikis or learner blogs can pay special attention to learners' new media elements such as menu item labels, navigation schema, and the location and type of embedded images, videos, and forms.

Finally, while this study focused on finding *evidence of metacognition*, not an *assessment of the strength of metacognition* demonstrated in the ePortfolio community, we felt the connection between identity as a learner, the learning experience, and the community was often underdeveloped. This suggests the need for an intentional, long-term approach to metacognitive development in the classroom and within learning communities such as this one. A few learners demonstrated strong metacognition through the creation, organization, and integration of ePortfolio content and their connection with the online community, so we hope that researchers and educators continue to explore approaches to metacognitive development with a focus on learners' creation and arrangement of new media elements in identity construction and collaborative learning environments.

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Learning how to learn together (L2L2): Developing tools to support an essential complex competence for the Internet Age

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Abstract: Learning to learn together (L2L2) is a complex competence requiring that all the group members are able to coordinate, regulate and plan the learning task by balancing issues of individual ability, motivation and expectations through constant dialogue. In this paper we report on a project to define the complex competence of L2L2 and to support it with a set of web-based tools and associated pedagogy, the Metafora Project. The system we develop embodies our theory of L2L2 and the results of our design-based research suggest that this system can succeed in making key elements of L2L2 explicit in the talk and actions of groups of learners.

Learning how to learn (L2L) is often referred to as the most important knowledge age skill since it equips people to adapt flexibly in a time of rapid change (OECD, 2001; 2004). However, we argue that the reality of Internet mediated learning is more about learning how to learn together (L2L2) with others than about learning to learn as an individual. L2L2 goes beyond L2L because it combines the dimension of task management, (how to organise complex inquiries with multiple stages and strands) with the dimension of social relationships (working with attitudes, expectations and identities in order to participate constructively in learning as a collective accomplishment). In this paper we report on a project that attempts to define the complex competence of L2L2 and to support it with a Metafora system (Wegerif et al, 2012), which includes a planning and reflection tool; a dynamic concept mapping space (Loll et al, 2011) and a chat, and associated pedagogy. In the first part of this paper we characterise L2L2, presenting elements of our design framework for teaching L2L2 and in the second part of this paper we describe design-based research used to test and refine the theory of L2L2 presented in the first part and to develop the working Metafora system.

Part 1: Characterising L2L2

Transferable learning skills and competences such as L2L have mainly been understood as the attributes of individuals. L2L2 is different because it is primarily the attribute of a group or collective. We hope that individuals who participate in one group acquire skills and competences that they can take with them when they go to work with other groups. However, these skills and competences are essentially social and do not exist outside of social interaction. Viewed through the analytic lens of the group, L2L2 is about group norms that support distributed leadership, mutual engagement, peer assessment, and collective thinking.

Teaching skills and competences to groups can be understood as a form of intentional culture change (Cobb & Bauersfeld, 1995; Wegerif, 2002). This process can be partly understood using a modified version of a commonly used schema in the teaching of individual skills: the process of moving from unconscious incompetence, through conscious incompetence, to conscious competence and on, eventually, to unconscious competence (Howell, 1982). The implicit norms of the culture in a classroom can be changed in a similar way. One important difference between teaching individual skills and changing cultures is that cultures are people plus tools including communications technology. This means that the tools that support communication within a culture are not only scaffolds that will fade away as new skills and competences are learnt but these tools can also be essential enablers of collective thoughts and actions (Pea, 1993). The Metafora system is designed to serve a dual role of supporting the teaching and learning of L2L2 and supporting the continuing practice of L2L2. This means that it provides tools to help make group norms explicit and change the culture but it also provides tools to help groups that are already good at L2L2 work together effectively and creatively.

In the first stage of this pedagogy the groups are made aware that they need to coordinate their work together but are not sure how best to do this, this initial stage is called the 'challenge' when they are presented with a complex problem. Explicit tools are provided by the Metafora system to support them. These tools, especially icons representing aspects of L2L2 (Table 1), make some of the implicit norms followed by effective groups, explicit. In the full system icons, representing aspects of L2L2, are combined with dynamic concept mapping spaces for discussions (LASAD, see Figure 2), microworlds and a pedagogical strategy.

Component	Explanation	Visual
Activity stage	Key stages of dialogic inquiry-based learning process, e.g. Explore, Reflect on process	

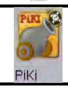
Component	Explanation	Visual
Activity process	Key activities to concretize the process of each activity stage, e.g. Report, Anticipate	
Attitude	Key intersubjective orientations to specify the group attitudes during activity stage and process, e.g. Critical, Ethical	
Role	Key roles to manage and mediate collaboration and cooperation between learners and groups, e.g. Manager, Evaluator	
Resource	Available resources for activity stages and processes, e.g. Group discussion map, Microworld artefact, etc.	
Connector	Key relationships between all the components, e.g. causal relationship, temporal relationship	

Table 1: Six Components of a visual language for L2L2

To unpack the complexity of the L2L2 competence, four key aspects are emphasised in our design of technology and pedagogy.

(1) **Encouraging distributed leadership moves**: Distribution of leadership in groups has both social (e.g., Crow, Hausman, & Scribner, 2002) and situational (e.g. Steed, et al, 1999) aspects. Each activity stage of the visual language represents a snapshot of the group learning situation, which reveals a need for different kinds of leadership distribution pattern. This awareness of distributed leadership around particular topics breaks down dominating coalitions, hierarchical relationships, social exclusion and isolation.

(2) **Mutually engaged through/around shared objects**: Shared object/artefacts provide a rich repertoire of referential anchors for mutual engagement and understanding. The shared model of the group learning process which is made explicit using the visual language plays a crucial role in supporting mutual engagement and creating a shared framework for collaboration.

(3) **Peer assessment for group awareness**: We argue that ability to take different general attitudes is a prerequisite for successful group learning, for example taking a creative attitude to attempt a speculative approach. The 'Attitude' components of the visual language offer students an opportunity to anticipate and consider what their likely responses might be, and implicitly, to consider any difference between the ideal response and their likely response.

(4) **Group reflection on the social dimension of learning**: To make this process of knowing explicit to the group, we identified three distinctive temporal opportunities for group reflection around an online discussion map:

Beginning: Reflecting on individual preferences, collective responsibility and intended level of participation.

Middle: Reflecting on emerging roles, norms and gaps between individual and collective outcomes.

End: Reflecting on original group learning interpersonal structure and emergent structure, intended individual learning outcomes and achieved outcomes.

Part 2: Design Based Research on the theory of L2L2

The theory of L2L2 described above was embodied in the first iteration of the Metafora system combining the visual language (Table 1), a dynamic concept-mapping dialogue space, microworlds and pedagogy. The exact format of each design-based research case study varied across the partners (in the UK, Spain, Israel and Greece), but all involved a class of students using Metafora tools (e.g. a planning and reflection tool, a discussion map tool and a chat) to solve a complex challenge. During the study, we video recorded groups working around computers. We then interviewed the participants in an open-ended way about their group learning experience. We analyzed the data to identify the emergent L2L2 themes relating to the four key aspects of L2L2 using interpretative discourse analysis influenced by socio-cultural discourse analysis. When possible we also used Key Event Recall analysis (Wegerif et al, 2010).

Results

Four examples selected from our different case studies illustrate how the Metafora tools and associated pedagogy support awareness of L2L2 towards the 'Conscious Competence' stage of culture change. Learners between 13 and 16 years old worked together after having been given a learning challenge that implied they had to plan and organise their learning together.

Episode 1: Distributed leadership moves around the planning and reflection tool

This episode is a group of students using an online chat to discuss how they should conduct their co-construction activity in a Microworld called eXpresser (Mavrikis et al, 2012), after they have use the tool to plan how they should allocate roles.

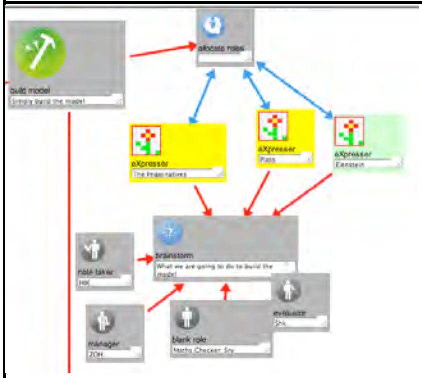
Role allocation with the visual language	Role negotiation in the chat
	ZOH: how many blue tiles have u got SHK: we have to coordinate with each other HIK: you seriously expect me to count them all? ZOH: yes ZOH: SRY you have to work with NOO HIK: ok, ZOH, you make sure the animation's coloured ZOH: ok SHK: and me? HIK: SHK, you check that the aniamtion works without messing up SHK: ok HIK: And I'll make sure the computer's model is coloured HIK: then we'll decide about the pattern later SRY: what shall i do? HIK: you'll have to discuss that with NOO, SRY SHK: oh right HIK: So ZOH, you're doing the My Model colouring, And I'm checking that the Computer Model is coloured.

Figure 1: Take responsible for different kinds of leadership moves

This discussion indicates an understanding of the function each one assumes when working together. Both the shared plan and the chat reveal that different students were responsible for different kind of leadership moves, for example, SRY was acknowledged at being better at the mathematical aspect of task, whereas SHK showed more managerial leadership moves.

Episode 2: Mutually engaged to elaborate the process of group learning

This episode is a group of students engaged in a dialogue around their visual model of group learning process. This dialogue demonstrates how Metafora visual language promoted and mediated the reflection about scientific process to solve the task.

Aln: so, in theory we are still here. We have not done anything, right? ((laughs))
Ada: yeh ... but from this, we should do an experimental design shouldn't we? Or something.
Aln: if
Ada: This is experimental design, right? [[looking for experimental design icon]]
Aln: wait, wait, wait. First are the hypothesis
Ada: We put and if we do better steps to follow first, and observe second
DNLA: if ... and reflect as well. Now we are reflecting, aren't we?
Aln, if also
Ada: thinking ...
Aln: here and to reflect put an arrow. So, after everything we've done we look in the mirror. Can I do it? ... [[requested photocopies of the icons in the DNLA]]

Episode 3: Peer assessment to co-construct a discussion map

This episode illustrates how the different 'attitudes' given icons in the visual language extend the group's capacity to create ideas and assess each other's ideas

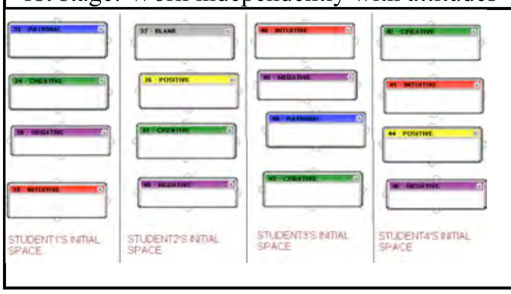
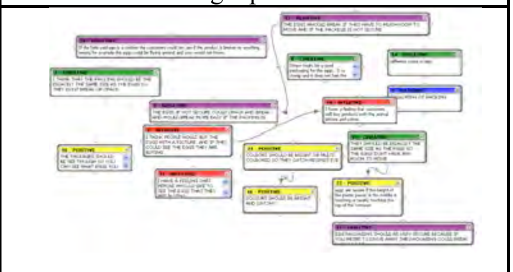
1st stage: Work independently with attitudes	2nd stage: peer review
	

Figure 2: From independent thinking with attitude to co-construct a collective discussion map.

In the post focus group discussion, we found an improved understanding of how to learn together in a web-based environment.

Interviewer: Were these colours useful?

> Charlie: Yes, they are all very useful, because you knowing what people are talking about. Sometime, you might find someone could write something in a blank one, you can think is it positive or something else?

We could find that the attitude types offered the students a way to structure their thinking together process, not in terms of the ideas, but in terms of the attitude they took to approach to the questions and tasks.

> Henry: I will put all our negative ideas on the top.
>
> Rose: Yes, I think we could delete No. 17, because it is the same idea to the No. 13. They are both about 'secure the eggs'.
>
> [[Rose pointed to the shared screen and Henry deleted text box No.17 as Rose asked.]]

Episode 4: Advancing ideas through an group reflection

This episode illustrates how interchangeably using different Metafora tools together enable a group of UK students to "*move their ideas bigger and better*".

> Researcher: Do you think discussion before planning helps you plan?
>
> Rose: Yes, definitely. We all have ideas, we all spoke about our ideas and in plan we move our ideas bigger and better, because we have all talked about it.
>
> Charlie: Yes you can look at LASAD and see your ideas again, and write down in the text boxes in the plan. Because you can change ideas and you can put extra ideas in.

By analyzing the video data, we find that continuity of children's experience of using the discussion mapping tool and the planning and reflection tool nurtures their reflection on their group learning process both at concrete level (i.e. task specific ideas) and abstract level (i.e. the visual language, the task general process).

Conclusion

This paper unpacks four key aspects of learning to learn together (L2L2) and proposes a visual language which was embedded in the web-based Metafora system to help enculture its users toward successful group learning . In most classrooms, learning to learn together requires culture change. The four episodes of Metafora-supported collaborative learning shown as illustrative example of our design-based research demonstrate how the four aspects of L2L2 are experienced by the students mediated by the external representations of group learning model and group discussion space. Such collaborative activities around these shared objects allow the new norms of L2L2 to become implicit over time as groups practice learning together in response to challenges in maths and science. The system we developed embodies our theory of L2L2 and the results of our design-based research suggest that this system can succeed in making key elements of L2L2 explicit in the talk and actions of groups of learners. Further research is continuing to explore the changes over time that happen in the use of metafora. Our hypothesis is that the use of explicit reminders and supports for L2L2 will reduce gradually as aspects of L2L2 become implicit within the shared culture of groups and classrooms.

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Computer-Supported Metadiscourse to Foster Collective Progress in Knowledge-Building Communities

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Abstract: This study investigates metacognitive conversations in two grade 5/6 classrooms that engaged in knowledge building about the human body using Knowledge Forum. The metacognitive conversations were supported by Idea Thread Mapper (ITM), which makes collective progress in online discourse visible for collaborative reflection. The analyses elaborate the processes of the metadiscourse and the teachers' role.

Introduction

Inquiry-based learning programs need to foster a self-sustained, progressive trajectory of inquiry among students in line with knowledge practices of real-word creative communities (Sawyer, 2007). Instead of relying on teacher-specified procedures, scripts, and resources of inquiry, students take on collective responsibility for monitoring and advancing their community's knowledge (Scardamalia, 2002). Previous research suggests the importance of metacognitive conversations—metadiscourse—as a means to fostering collective responsibility. Through metadiscourse, students review the conceptual landscape generated through their knowledge-building discourse, monitor core problems and goals, reflect on what they have achieved as a community, and identify deeper goals and collaborative actions (Zhang et al., 2009). Despite the importance of metadiscourse, this discourse pattern is rarely seen in computer-supported collaborative classrooms (van Aalst, 2009). In online discourse through threaded discussions, chatting, and messaging, student ideas are distributed across individual postings over time (Suthers et al., 2008). It is difficult for students to understand the conceptual landscape of their collective work, to identify knowledge advances, and to reflect on gaps and challenges.

To represent collective knowledge in extended online discourse, we recently created a timeline-based collective knowledge-mapping tool: Idea Threads Mapper (ITM). An idea thread represents a line of inquiry composed of a series of conceptually related discourse entries that address a shared focal problem, extending from the first to the last discourse entry (Zhang et al., 2007). Interoperating with Knowledge Forum (Scardamalia & Bereiter, 2006), ITM helps students to review shared focal themes, as communal goals, that have emerged from interactive discourse and identify and review ideas contributed to address each focal goal over time. ITM integrates three levels (or units) of ideas in knowledge-building discourse: an *idea* contributed in a discourse entry (e.g., Knowledge Forum note), an *idea thread* consisting of multiple entries addressing a focal issue, and a *network of idea threads* for a whole inquiry initiative (Figure 1) (see Chen et al., 2013 for more details). This study investigates how ITM can be used to support metacognitive conversations among young students for sustained knowledge building. Our research questions ask: how do young students engage in metadiscourse to co-construct idea threads to represent and advance collective knowledge in extended discourse, and with what support from their teacher?

Method

This study was conducted in two grades 5/6 classrooms, each of which had 22 students who investigated the human body systems over a two-month period. The two classrooms were taught by two teachers: Teacher A in her first year and B in his sixth year working with knowledge building/Knowledge Forum. By analyzing these two classrooms as two cases, we attempted to discover a grounded theory (Glaser & Strauss, 1967) about how ITM-aided metadiscourse is conducted to support knowledge building. The classroom processes integrated knowledge-building conversations, individual and group-based reading, student-designed experiments and observations, and interactions in Knowledge Forum. The researchers worked with the teachers to design procedures of ITM-aided reflection, which was implemented around the midpoint of the inquiry using approximately two hours to review progress and plan for deeper inquiry.

For data analysis, the ITM-aided reflection session in each class was video recorded. The videos were transcribed and analyzed using a narrative approach to video analysis (Derry et al., 2010). Two researchers first browsed the videos and transcriptions to develop an overall sense of the reflective processes, and then identified "digestible" chunks in the videos—major episodes of the reflective conversations by which students identified and negotiated "juicy topics," selected important discourse contributions, synthesized progress, and planned for deeper inquiries. These chunks were contextualized and linked to develop a storyline for each classroom, showing how the two communities engaged in metadiscourse on collective knowledge progress. Further analysis was conducted focusing on the teachers' conversation turns to understand how they scaffolded the metadiscourse and co-reflection. Through a grounded theory approach, two researchers developed raw codes to capture the roles of the teachers. They then shared and discussed the raw codes in relation to the data coded, resolved disagreements, and classified the codes into larger themes that indicated different patterns of scaffolding (see Results for the patterns). Complementing the video data, we interviewed five students from each classroom before and five different students after the ITM-aided reflection. The interview focused on student awareness of the important themes explored by their community, advances, problems, and experience with ITM.

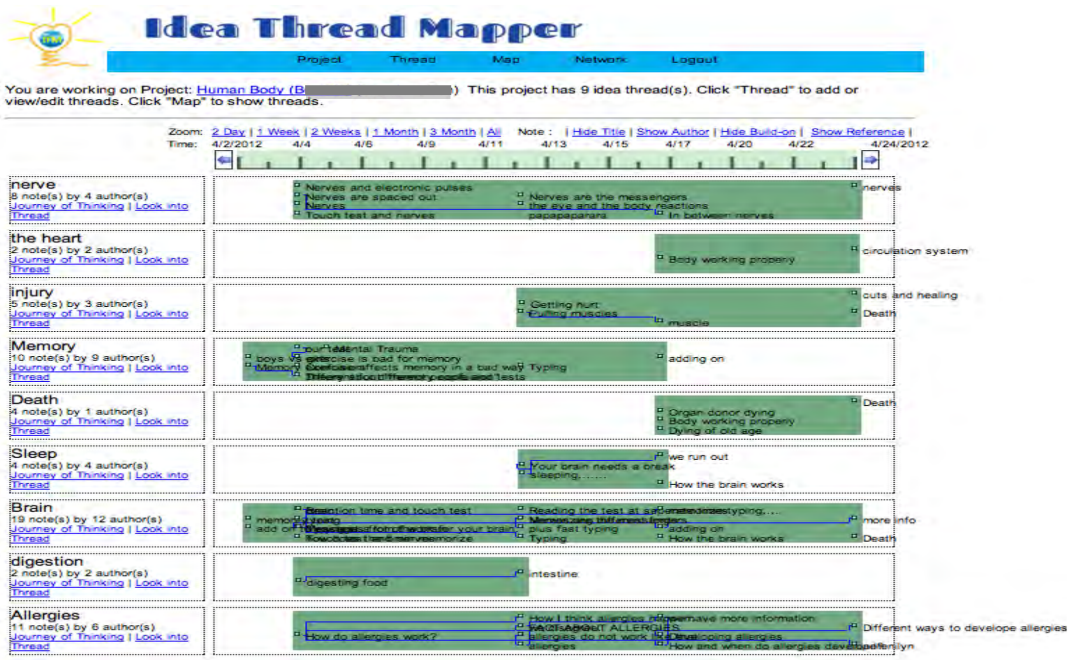

Figure 1. A map of idea threads created by a grade 5/6 classroom studying the human body. Each stripe represents an idea thread addressing a focal theme. Each square in the threads represents a note, and a line between two notes represents a build-on link.

Results

The video analysis revealed multi-level collaborative interactions in the metadiscourse that gave emergence to collective knowledge. Figure 2 shows the multi-level, emergent interactions captured in class B's metadiscourse aided by ITM, with similar processes observed in class A's videos.

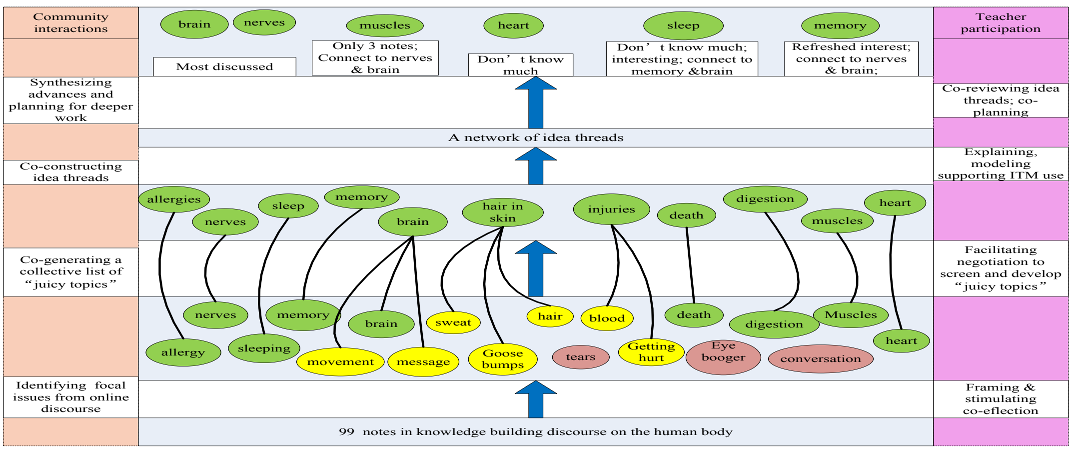

Figure 2. Multiple levels of emergent interactions to reflect on collective knowledge progress.

Identifying Focal Issues and Co-Generating "Juicy" Topics

Enabling emergence of ideas at the micro level, students engaged in online knowledge-building discourse and face-to-face interactions to generate ideas about how the human body systems work, with 139 Knowledge Forum notes created in class A and 99 in class B prior to the ITM session. In the ITM-aided reflection, students reviewed and rose above diverse ideas in the knowledge-building discourse by identifying core "juicy topics."

In class A, facilitated by a relatively junior teacher, this was done through two phases: Students first individually reviewed their Knowledge Forum discourse and wrote down important themes in their notebooks. Analysis of the notebooks indicated that each student recorded one to three topics. They, then, shared the topics to generate a collective list of "juicy topics" that represent the community's collective focuses. Classroom B, facilitated by a more experienced teacher, integrated the above two phases into a whole class conversation in which students proposed major topics and co-reviewed the proposals to construct a shared list of "juicy topics."

The teachers' role to support the co-emergence of "juicy topics" focused on framing and stimulating co-reflection. They highlighted the epistemic need to review and organize collective knowledge advances, such as by saying: *"In just about like three weeks, ...we got 99 notes, and I was trying to look at this [Knowledge Forum view] today and I realize that...it's big and complicated… There's a new way of kind of organizing some of these ... into a way that might help us to understand what we have done, what we like to…do more. Um, I want to ask, ... what are some big, 'juicy topics' that have come out here?"* (Teacher B) The teachers further discussed about what might be considered as a "big idea" or "juicy topic:" *"big ideas that you came across in the view that will help us really understand important things about the human body and help us to sort of progress what we know as a class."* (Teacher A)

Students then proposed topics of inquiry based on their personal understanding of the community's discourse. Students in class B proposed a total of 22 possible topics for the community to review, including allergies, nerves, sleeping, and so forth (see Figure 2). These topics were proposed for collaborative review and screening to judge the importance, elaborate the scope of issues explored, and discuss their relations to other issues investigated. The teachers facilitated and participated in the co-construction of core, "juicy topics" and recorded the accepted proposals on a blackboard. Some of the topics proposed were discussed and directly accepted by the community (e.g., allergies, death). Broad topics (e.g., brain) were elaborated and expanded to highlight the more specific focuses (movement, memory). A few topics proposed using intuitive language (e.g., getting hurt, bleeding, healing) were elaborated to clarify the deeper, scientific ideas (e.g., injury, immune system). Meanwhile, a few topic proposals, such as eye-booger and tears, were commented as minor issues. Through such reflective conversation, Class B generated a collective list of 11 "juicy topics:" allergies, brain, sleeping, nerves, hair in skin, memory, digestion, death, injuries, heart, and muscles. Class A generated a collective list of eight "juicy topics," including the brain, messaging in the body, central nervous system, heart, muscles, nutrition and eating, and immune system.

Co-Constructing Idea Threads by Reviewing and Selecting Idea Contributions

To review knowledge building progress related to the "juicy topics" identified, students created idea threads using ITM. In both classes, the teacher explained the purpose and intention of ITM, co-constructed one idea thread with the whole class, as an example, formed voluntary small-groups to construct idea threads, and provided technical assistance. For example, teacher A first introduced and explained ITM: "*We are going to sign in ... this really exciting new tool… If I say an "idea thread," you know what I mean? [Several students talk] Sort of like a chain of ideas that link to each other and that…starts with a question or idea and builds more and more knowledge… and hopefully also more questions as the idea moves along…"* Focusing on a focal topic (e.g., messaging in class A and allergies in class B), the teacher worked with students to decide what key terms should be used to search for Knowledge Forum notes using ITM, review the notes, and selected notes that contributed to the community's understanding. ITM displayed the notes selected as an idea thread, which became accessible and editable by all the community members. Following the processes to construct the above thread, as an example, students then worked as small groups, each of which created an idea thread focusing on one of the topics they previously identified. The teacher's role in this process focused on co-reviewing idea contributions, co-interpreting patterns of conversations in each thread, and providing technical support. Displaying idea threads on a timeline with options to zoom in/out helps students to see idea connections and build-on over time.

Synthesizing Collective Advances and Co-Planning for Deeper Work

With all the idea threads mapped out and projected on a screen (see class B's map in Figure 2), the teacher then worked with the whole class to review their collective work in the different lines of inquiry, reflect on major advances, and identify weak areas. They looked at the length of each idea thread and density of build-on links, and discussed how the different streams of inquiry related to one another. For example, by reviewing their idea threads map, students in class B found that they had conducted long and intensive discourse about the brain, nerves, and allergies, which were core topics that they were aware of prior to the ITM reflection. However, they were surprised to find that the thread on memory had engaged extensive discussions (10 notes by nine authors), and that the thread on heart, a critical part of the human body, only had two notes, one of which was shared with the idea thread on death. Based on the co-reflection, students discussed areas that were interesting and needed deeper work, including the brain, nerves, heart, and sleep (see the top of Figure 2). Similarly, teacher A facilitated metacognitive conversations among her students as they co-examined their map of idea threads. As an important insight, they realized that the human body is a system where everything is connected and that there are some parts (heart, messaging system) that seem important and tie all the other parts together.

Students further worked in small-groups to write "Journeys of Thinking" that included three sections: our problem, our progress, and we need to do more. Each section has a set of scaffold supports. For example, synthesizing their progress in the idea thread on messaging in the body, students wrote: *"[We used to think:] ... that the body just moved by itself. You just thought it, and it happened! [We now understand:] that the nerves help you move; your brain sends the message that you want move; the vertebrae help you move and send messages."*

As the student interviews suggest, the reflective conversations aided by ITM increased student awareness of their collective knowledge. Each student identified 2 to 3 major topics of inquiry in the individual interview. Idea threads constructed by the community highlighted many more themes (eight in class A and nine in B), bringing important focuses and ideas of the community to the attention of all its members. ITM further helped students to understand their collective trajectory of ideas through its temporal display of notes and build-on links within each idea thread and across the whole knowledge building initiative, and through co-summarizing "Journeys of Thinking" about advances and deeper issues. As the students commented, "*I think that it can help you know what you should study more and look into more*."

Discussion

The analyses resulted in a grounded theory about ITM-aided metadiscourse as multi-level emergent processes. The fifth- and sixth-graders co-constructed core "juicy topics" based on their monitoring of ideas in the extended knowledge-building discourse; reviewed and selected important ideas addressing each juicy topic to construct idea threads; rose above the specific idea to co-summarize "Journeys of Thinking"; and co-reviewed the map of idea threads to identify advances and weak areas for the whole knowledge building initiative. Such reflective processes helped to increase student awareness of their community's knowledge and inform collaborative, deepening efforts to further advance it. The teachers' role to support the metadiscourse focused on (a) framing and stimulating co-reflection such as by highlighting the epistemic need to review collective knowledge and elaborating what counts as big ideas or "juicy topics," (b) explaining and modeling ITM use (e.g., what makes an idea thread) and providing in-situ technical assistance, (c) facilitating negotiation to co-construct "juicy topics" and review contributions, (d) co-reflecting on the idea threads to synthesize progress, and (e) co-planning knowledge building in areas that needed deeper work. Building on these preliminary findings, we are conducting further design experiments to engage students in ITM-aided metadiscourse on an ongoing basis and examine the impact more comprehensively by using an expanded range of research measures.

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Understanding the Teacher's Role in a Knowledge Community and Inquiry Curriculum

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Abstract: This study examined teacher's role in a Knowledge Community and Inquiry (KCI) curriculum. Three science teachers and their students in a climate change curriculum unit involved in this design-based research. Curriculum design documents and video recordings of teacher-students interactions were the sources of data. Grounded theory coding techniques and a video coding scheme were applied to the analysis of data. Analysis examined the roles that teachers played in the KCI curriculum as well as the teacher-students interactions. Teachers played a predominantly logistical role in the beginning of the enactment of this KCI curriculum, followed by increasingly pedagogical practices.

Teachers are critical to the success of any reform-based curricula that often require them to substantially change their perspectives of teaching and learning to adopt an innovative pedagogy (Blumenfeld et al., 1991; Fishman et al., 2004). Prior research has advanced one promising approach to teaching and learning (Bielaczyc & Collins, 1999; Slotta & Najafi, 2010) that transforms classrooms into knowledge communities with the support of technology where students can acquire the 21st century skills (Brown & Campione, 1996; Scardamalia & Bereiter, 1992). This knowledge community method requires that teachers transform their classroom into a community of learners. Teachers are often suggested to play a role of "coach" or facilitator of knowledge construction, supporting students to construct their own knowledge within a complex range of activities (Blumenfeld et al., 1991; Brown et al. 1993; Brown & Campione, 1994; Hewitt & Scarmadalia, 1998; Hmelo-Silver & Barrows, 2008; Scarmadalia, 2002). However, it is challenging to describe how such pedagogical practices can be achieved in the classroom by teachers. Indeed, the research literature has very little to say about the specific role of teachers (Putnam & Borko, 2000). There is no research has specifically addressed what teachers are actual doing and what they should be doing in a knowledge community approach.

The knowledge community approach has not enjoyed much success at the secondary level (Staples, 2007), partly because of the heavy content expectations teachers must address, the traditional assessments students must perform, and the challenging forms of teaching practice (Slotta & Peters, 2008). In order to make this method more accessible to teachers, Slotta and his colleagues (Slotta, 2007; Slotta, & Peters, 2008) have introduced the Knowledge Community and Inquiry (KCI) model that integrates a dimension of scaffolded inquiry within a knowledge community approach. In the KCI model, students first engage in collective knowledge construction activities to explore and examine their own ideas, which are then aggregated into community knowledge base. Next, students work collaboratively in scaffolded inquiry activities, drawing on knowledge elements from the community knowledge base to produce new elements to that knowledge base and specific outcomes that serve as assessments of individual understanding.

Early implementations of the KCI model have been successful (Slotta & Peters, 2008). Nevertheless, their approach has ignored any specific description of the teacher's role within the model. To inform such a description, the present study has recorded large amount of videos of teachers' enactment of KCI curriculum for the purpose of examining the detail of teachers' interactions, and to analyse the role they play at various points in a KCI curriculum. The objective of this study is to create a fine-grained description of the teacher's role by analysing the curriculum design documents and the teacher-students interactions in the practical enactment of a technology-infused science curriculum unit. The following research questions have guided this study:

1. What roles does the teacher play in the classroom during a KCI curriculum?
2. What kinds of interactions with students does the teacher implement during different phases of KCI?
3. How does the teacher scaffold students' inquiry and collaboration in a KCI curriculum?

The study

This study was conducted to understand the teacher's role in a global climate change curriculum unit that was designed according to the KCI model. The overall research program employs a design-based methodology (Brown, 1992; Collins, 1992) where the investigations are embedded within a deeply contextualized curriculum. Because teacher's understanding of the theoretical position and faithful enactment of the curriculum are critical, a co-design process (Shrader et al., 2001; Roschelle & Penuel, 2006) was employed where researchers and teachers worked in close collaboration in the development of research materials and instructional designs. The research site of the study is a private secondary school in Toronto. Three teachers and their students from five class sessions at grade eight participated in this study. In this paper, we present two analyses that we conducted.

Curriculum Design Analysis. The goal of this analysis is to identify the teacher's role as it was designed (explicitly and implicitly) within the curriculum. In this analysis, we examined the curriculum design documents, teacher's lesson plans, and emails between the teachers and the researchers. We used open coding and axial coding techniques in the grounded theory method (Strauss & Corbin, 1998).

Teacher-student Interaction Analysis. The purposes of this analysis are: 1) to describe the roles that the teachers played in their practical enactment of the designed KCI curriculum; 2) to identify teacher-student interaction patterns. By reviewing literature, we developed a two-level coding scheme (Table 1) to analyse video recordings of teachers' classroom enactment. At present, we have analysed the video from the first class period only, across all five sections of the class, although this analysis will be scaled to 20 or more class periods.

Table 1: Coding scheme for video analysis

Code		Meaning
Logistical: WCI, SGI		Teacher provides procedural or logistical information to students in the whole class (WCI) or in small groups (SGI), such as managing students' behaviour, helping students solve technical difficulties, giving instructions on how to use software, etc.
Conceptual: WCI, SGI		Teacher talks about science concepts to students in the whole class or in a group.
Pedagogical: WCI, SGI	Connection	Teach helps students to recall or connect to prior knowledge, experience, or personal relevance.
	Context	Teacher sets the context for following instruction or activities, such as introducing learning activities, talking about the content that will be learned and agenda, etc.
	Elaboration	Teacher elicits students' thinking; asks or helps students to elaborate their thinking, explain their own idea clearly, or think beyond what they are learning.
	Evaluation	Teacher evaluates, assesses, or monitors students' progress, their understanding of concepts, their learning outcome, and praise them.
	Guidance	Teacher guides, explains, or engages student in inquiry activities or process; give directions or suggestions on how and what to do next in order to continue their learning process, how to find learning resources, etc.
	Modelling	Modelling of reflective thinking, connecting of knowledge, collaborative working, and building on other's ideas, etc.
	Question	Quick responses to student's questions
	Reflection	Encourage or request students to reflect on their learning activities, learning process

Results

Curriculum Design Analysis

The following categories of teacher's role were identified from the coding of the designed curriculum: content lecturing, evaluating students, introducing learning activities, making connections, explanation or elaboration, and classroom management role. These reflect the intention of the design team, with regard to what activities we felt the teacher should be engaged with, and when. It is important to conduct this analysis, so that it can be compared with observations of the enactment, to inform the more abstract or general model (i.e., KCI).

Content lecturing is the most frequent role identified for the teacher within our design. Content lecturing happens mostly during the collective knowledge construction stage of KCI where the teacher would lecture about various science concepts and principles relating to climate change: carbon dioxide and greenhouse effects, carbon sinks and carbon sources, heat transfer, ocean circulation, weather patterns, and many others.

Evaluating students is an important role articulated for the teacher within our design. Teacher evaluates students in two ways: first, to give students periodic quizzes during the implementation of the curriculum and a final examination at the end of this unit; second, to evaluate students' contribution to the advancement of community knowledge. In our design, the teacher should examine individual student's editing history of the regional pages, issue pages and remediation pages and give marks based on the quality of each student's editing. To implement this second type of evaluation properly, teacher needs to introduce students the rubric that will be used in evaluating their editing contributions to the wiki pages.

Introducing the learning activities and explain in detail how they will be enacted was another important element of our design, since the particular learning activities within this curriculum unit were quite novel (e.g., editing wikis). This includes the demonstration of any technologies used in the curriculum unit.

Making connections refers to that teacher should help students to connect the climate change issues they are investigating to the science content they are learning and to connect climate change science concepts to climate models. In our design, this connection role happens when students collectively construct community knowledge base.

Elaboration refers to a role that the teachers play to help students gain deeper understanding of content. The teachers may highlight or clarify science concepts and principles; follow-up on things that the teacher thinks the students have difficulty in understanding; explain the role of a science model. Facilitating and leading student discussion on climate science content or remediation plans are also considered as elaboration role.

Coordination was a final role described for teachers: grouping students, assigning students to peer review groups, giving students class time to complete their reflections, assigning reference topics, etc.

Teacher-student Interaction Analysis

Table 2 shows the frequency, the total time, and the average time (in seconds) teachers spent on each type of interaction. Table 2 indicates that logistical interaction, happened 166 times in small group and in whole class, is the most frequent form of interaction between the teacher and the students. This means that the teachers interacted with students more often provide logistical or procedural assistances to students. The emphasis on logistics and pedagogy is due to the fact that the video data we analysed so far are only from the very first class period of the curriculum, where teachers needed to introduce the technology that used, help students solve technical difficulties, and explain the activities.

Table 2: The frequency, average time, and total time teachers spent on each typo of interaction

Code	Frequency	Time	Average
SGI_Conceptual	1	33.92	33.92
SGI_Logistical	89	2002.01	22.49
SGI_Pedagogical	18	392.93	21.83
WCI_Conceptual	6	289.72	48.29
WCI_Logistical	77	2765.11	35.91
WCI_Pedagogical	68	3249.11	47.78

A more detailed coding of the pedagogical content of student-teacher interactions will reveal more information about the teacher's role within a KCI curriculum or a knowledge community approach, more generally. Figure 1 displays a finer grain coding of the pedagogical interactions (WCI_Pedagocial and SGI_Pedagogical, from Table 1 above) from the three teachers in this first class period. While all three teachers clearly performed many "Whole class" Context and Guidance interactions, this is reasonable because at the beginning of a new unit the teachers need to set the learning context and provide students with guidance about the activities. Figure 1 also suggests differences among the three teachers in terms of their interaction patterns. For example, Teacher 3 shifted his interactions with student very often, 40 times for Teacher 3 vs. 31 for Teacher 1 or 15 for Teacher 2. While these differences are not statistically significant, the coding is in the early stages, and these patterns will be a focus of future analysis. These preliminary results suggest that in the first activity the teachers interacted with students more often for the purposes of 1) providing logistical or procedural assistances, and 2) setting the learning context and guiding students. Also, teachers perform pedagogical interactions differently. We believe that as more data are analysed, they will reveal important relationships between the nature of the KCI model, the specific curriculum topics and interventions, and the kinds of interactions that occur in the classroom.

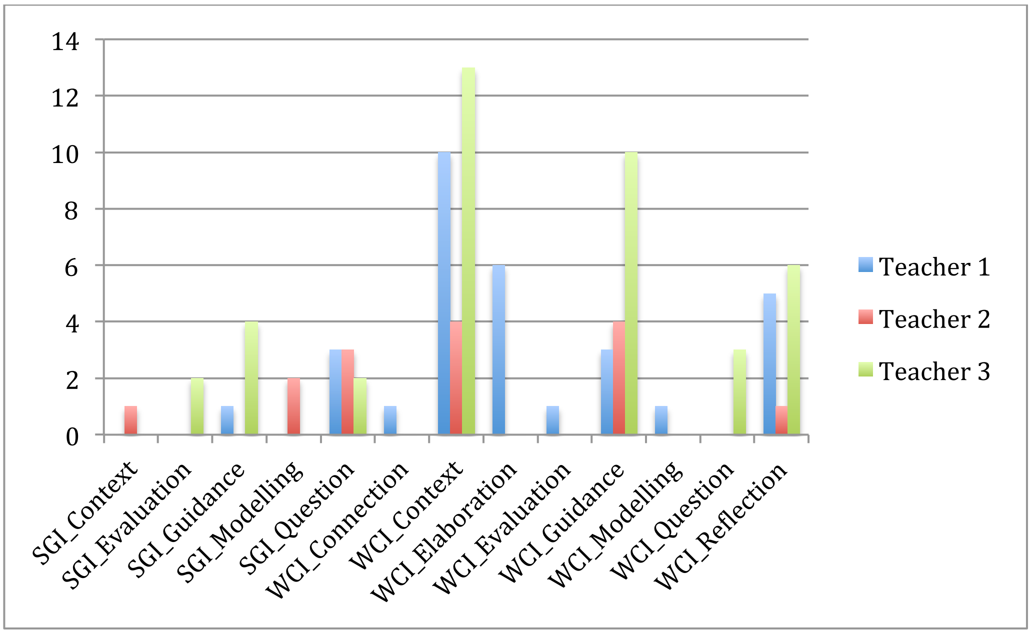

Figure 1. Frequency distribution of each type of interaction among the three teachers

Discussion

Understanding the dependencies of innovations on dynamics within the classroom is an important goal in learning sciences research. Even if the classroom teacher is deeply involved in the design of the innovation (i.e., in co-design), the true nature of our interventions only takes shape during enactment. Hence must address these dependencies. This study is creating a fine-grained description of the teacher's role in the KCI model by examining three teachers' enactment of a climate change curriculum unit. Results so far indicate that the roles played by teachers during curriculum enactment differ, at certain degrees, from what the design had specified. They played more roles than we had designed during the curriculum design stage, with a lot of logistical and procedural interactions, which were not anticipated in the design. Ideally (in subsequent activities), teachers who enact a knowledge community approach should spend more time on pedagogical interactions to set the learning context, guide students, elaborate students' thinking, connect students with previous experiences, evaluate and monitor students, and encourage reflection about learning activities.

Our future analysis will extend the teacher-student interaction analysis to 20 class periods. As we code the more substantive activities (i.e., in the middle and end of the curriculum) we anticipate that the pattern of interactions will vary. We are also analyzing the teachers' background knowledge and see how this variable affects their interactions with students.

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Design of a Collaborative Learning Platform for Medical Doctors specializing in Family Medicine

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Abstract: Access to occupational knowledge exchange and collaborative learning is highly restricted for doctors in specialty training for general practitioners/family medicine (GPs) in Germany, since they are not organized in coherent vocational training programs. Based on an analysis of the target group's needs, this paper presents our pedagogical concept and a first prototype of a community sharing and knowledge building platform for this target group. This platform can be accessed independently of space and time and shall support collaborative learning with peers.

Introduction

In Germany, doctors need a medical specialization in family medicine to work as general practitioners (GPs). The German Medical Association has empirically shown that there is an increasing lack of GPs in eastern Germany, since 38 % to 48 % of the current GPs will retire within the next ten years and there are not nearly enough graduated doctors specializing in family medicine (Kopetsch, 2010). The affected federal states are mostly spread across large rural areas. Thus, GPs and their trainees are geographically dispersed and have to overcome broad distances to interact with peers. The curriculum of specialty training in family medicine takes at least five years and is regulated by 17 federal medical associations in partly different ways. In a typical trajectory, doctors in special training start with positions in hospitals to fulfill the general requirements that could also be used for other specializations. The phase of working in a GP's office mostly takes place later in the training. Because of the broad spectrum of tasks required in the curriculum of family medicine, doctors in training work in at least four different locations in hospitals and medical practices. These are often separated by large distances and not connected. The five year training is self-organized, which implies that the doctors have to find jobs on their own initiative, partly for periods of only six months. This takes much time and effort (DEGAM, 2009). Except of local initiatives, these conditions often cause doctors in training to be isolated and not supported by organized communities of practice. Peer contacts are hard to establish and often hampered by job changes. Missing opportunities for networking highly restrict the occupational knowledge exchange as well as collaborative learning in peer communities, so that missing team work is often criticized (DEGAM, 2009). To address these problems and needs, the project KOLEGEA (http://www.kolegea.de/), which is facilitated by the German federal ministry of education and research, aims to support doctors specializing in family medicine by providing a platform for collaborative learning in occupational, social communities.

KOLEGEA's pedagogical approach

In our pedagogical approach, we focus on collaboratively working with shared cases in the spirit of problem-based learning (PBL). PBL was originally developed to "facilitate the acquisition and practice of clinical reasoning skills through exposure to real patient problems" (Distlehorst & Barrows, 1982) and has been introduced to many medical curricula since the 1970s (Barrows, 1996), thus many graduated doctors are familiar with it. In PBL, students work collaboratively in small groups to solve realistic, ill-structured problems (Barrows, 1996; Hmelo-Silver, 2004). Information needed for solving the cases is acquired through self-directed learning. The teacher's or "tutor's" role lies in facilitating the PBL process rather than transferring medical knowledge. Yet, in addition to being experts on PBL tutoring, good tutors are also considered to be experts in the area of study (Barrows, 1996). PBL involves loops on problem formulation, self-directed learning, problem reexamination, abstraction and reflection (Koschmann et al, 1992). Goals of PBL are the construction of extensive and flexible knowledge, effective problem-solving skills, self-directed, lifelong learning skills, collaboration skills and intrinsic motivation to learn (Hmelo-Silver, 2004).

The GP specialty training is based on learning by solving real problems/cases in every day working life under the supervision of experienced GPs who are accredited specialist-trainers. Thus, learning already is problem-based, self-directed and based on intrinsic motivation. Our goal is to support this through an online community platform for collaborative learning and knowledge building in occupational social communities which aims at overcoming the problem of missing opportunities for occupational knowledge exchange and collaborative peer learning.

For this purpose we build on the existing intrinsic motivation of the trainees to solve real-world cases. Hence, key aspects of the platform are the autonomous creation of anonymous case descriptions and problem formulations based on working experiences as well as the facilitation of discussions and cooperative finding of solutions in small groups. To support these group processes, the case studies should be linked to applicable medical guidelines, studies, articles and web pages (self-directed learning). This approach also has the potential of training the practical appliance of guidelines to actual cases. To provide a hands-on experience, case studies can be augmented by anonymized multi-media contents like pictures (e.g. X-rays or CT scans), sketches (e.g. position of aches or wounds), videos (e.g. motion sequences) and sounds (e.g. untypical coughing noises) that are approved by the patients. While we focus on learner-generated use cases, there will be an initial collection of realistic multi-media case studies to prevent cold start problems and provide best practices.

Social interaction as well as collaborative learning is supported on different levels. Our focus for collaborative learning is the small group. There are two types of small groups with regards to the tutor. For the challenging period of working at a GP's office (see next section) tutors ("mentors") are experienced GPs, who not only facilitate the PBL-process, but also support the trainees based on their experience in finding high quality solutions. These groups provide their own cases and collaboratively identify possible solutions based on medical guidelines. After solving a case, the results are quality controlled by the mentor and can be published in the platform's archive to be used as "emerging learning object" (cf. Hoppe et al., 2005) for the whole community. Thus, our platform also supports a knowledge-building community in which members create shared knowledge artifacts on the basis of current research and theory in the context of authentic practice (cf. Steinkuehler et al., 2002). Furthermore, the platform admits and hosts self-regulated small groups without constant support of an experienced GP. In these groups a trainee who is experienced with PBL can adopt the role of the tutor. In addition to discussing own cases, archive cases can be used to train the appliance of specific medical guidelines or to extend knowledge in certain fields. For example, these groups are adequate for trainees preparing for their final exam or maintaining contacts.

Apart from the work in small groups, there will be tools for community support like forums, which can be used for occupational, but also social exchange. Following Steinkuehler et al. (2002), we consider group discussions to be asynchronous and threaded, since this can produce discussions and results of higher quality than synchronous communication and is more flexible regarding time. To particularly aid trainees in rural areas and areas with low infrastructure, we support mobile recording of multi-media notes as well as mobile services to access to the portal.

Analysis of the target group

To decide, whether such a platform is suitable for the target group and which contents are considered especially important, we used an online questionnaire, receiving 73 responses from family medicine trainees. In addition we conducted 15 qualitative phone interviews with stakeholders, including experienced trainers and representatives of medical associations. Since there is no monitoring of the number of doctors in specialty training, the accurate size of our target group is not known. In 2008 as well as 2009, there were around 1200 acknowledgements of new GPs in Germany (Kopetsch, 2010). Extrapolating this number regarding the five year training, the target group consists of at least 6000 trainees.

The target group's attitude towards computers was measured based on FIDEC and the confidence based on COMA (Richter et al., 2010). The trainees show a very positive attitude towards computers as instruments for working and learning and are rather confident of their usage (see Figure 1). They are also open for new technologies, thus, 59% could imagine tablets and 32% smart pens as potentially helpful for their daily work, although only few are familiar with the usage of tablets (11%) and non with smart pens.

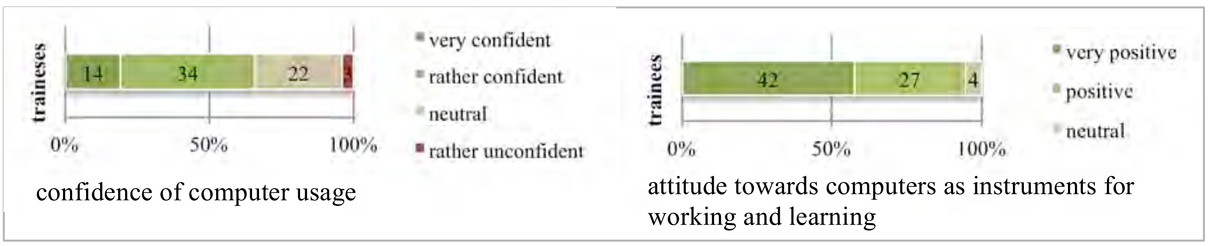

Figure 1. Confidence of computer usage and attitude towards computers.

We found that the majority of trainees uses the internet for gathering information rather often (61.6% daily, 31.5% several times a week) and 71.2% use online learning platforms in general. Regarding online learning, they especially like the independence of time (92%) and space (89%) and the easy accessibility of information and materials (84%). Reasons for not using online learning platforms are mainly missing opportunities (16.4%) and awareness (5.5%). The interviews show that in order to enable trust and collaborative learning trainees and trainers request a platform to be a protected zone only for doctors, without access for patients or laymen. Furthermore, there has to be a quality control of the contents. During the interviews, trainers and representatives of medical associations expressed the desire for a stronger integration of medical guidelines into specialty training. A well-known approach for practical medical training is the discussion of case studies: 90% of the polled trainees consider them suitable for learning, 81% can image to derive therapy recommendations, 70% expect support for diagnoses and examples for uncommon deseases, 62% consider them as a medium for discussing contents with collegues and 48% as useful for safeguarding difficult decisions. The interviews highlight that learning with case studies reduces the level of abstraction and enables working based on symptoms (a main approach in general practice) and not only by taking typical desease patterns into account. To create a hands-on experience with case studies, they should not only contain text, but also multi-media objects like pictures, videos and sounds. According to the survey conducted with trainees, they are familiar with many recording and editing devices and they already use them for work (see Figure 2).

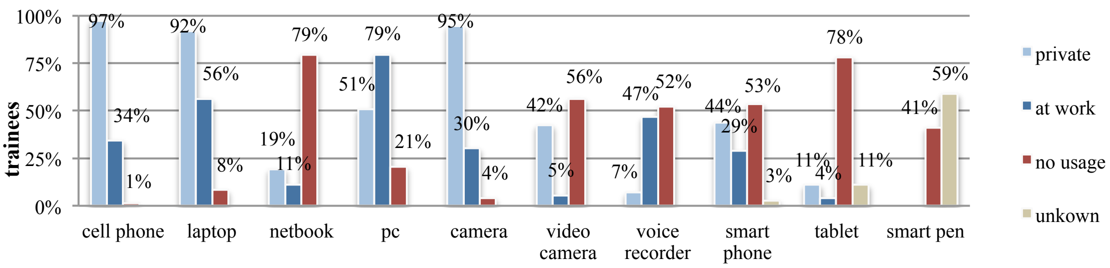

Figure 2. Trainees‘ tool usage.

Furthermore, the interviews show that the phase of working in a GP's office is especially challenging. Doctors starting their specialty training are usually familiar with working in hospitals where they can consult different specialists, have many diagnostic opportunities, treat only patients related to one field at a time and concentrate on a limited number of patients. Whereas in a practitioner's office, they only have one reference person, highly restricted diagnostic opportunities as well as a diverse and unrestricted field of consultation purposes and disease presentations. Furthermore, they treat a high number of patients within little time, requiring fast decisions. Thus, there is often uncertainty and an unsatisfied need to discuss unusual or problematic cases, e.g. to receive feedback on alternative diagnoses or therapies to support the decision-making process.

Summarizing these results, the target group is ready to use the planned platform regarding their technology acceptance and competence, but stress that trust is an important factor. To enable trust on a social level, only doctors registered as members of the Medical Association (registrations mandatory for all German physicians) will have access to the portal and face-to-face kickoff workshops will be conducted. As considered in the pedagogical approach, learning by discussing case studies is well established and will therefore be central in our platform. Furthermore, there will be support to access and link medical guidelines to improve their integration into specialty training. Since the phase of working in a GP's office is especially challenging, PBL groups in this phase will be supported by experienced GPs.

Prototype of the KOLEGEA environment

The KOLEGEA environment will consist of a web portal and mobile (tablet, smart phone and smart pen) applications for accessing the portal and multi-media note taking. Currently (after one year of the three year project) there is a first prototype of the portal focusing on the creation and representation of multi-media case descriptions and their discussion as well as a tablet app for multi-media note taking for medical cases. Both tools have already been exposed to the target group on five occasions. The feedback was positive, but it was pointed out that in order to use the system trainees require time provided by their training institutions or employers.

Regarding the role of technology, the mobile note taking app is conceived as a digital replacement for analog pen and paper notes with the added value of multi-media integration as well as digital availability of notes and media for the creation of authentic case descriptions. Since doctors have limited time during a patient consultation, we expect them to only collect basic information on the patient's case using the tablet and complete the case description using the web portal on a PC or laptop afterwards. The portal provides access to the virtual community and its knowledge artifacts (user-generated contents as well as links to artifacts of current research). Figure 3 shows an example of a case description, its discussion and links to knowledge/learning resources used in the discussion. The case description is structured based on the phases of the medical consultation containing information about the anamnesis, examination, diagnostic investigation, tentative diagnosis and procedure. Photos, handwritten notes and text, but also videos and sounds can be integrated to a case description and shared with the small group. Discussion is enabled with a forum like tool, which facilitates comments on the problem as well as on the comments of other group members. Furthermore, knowledge and learning resources relevant to the problem can be shared.

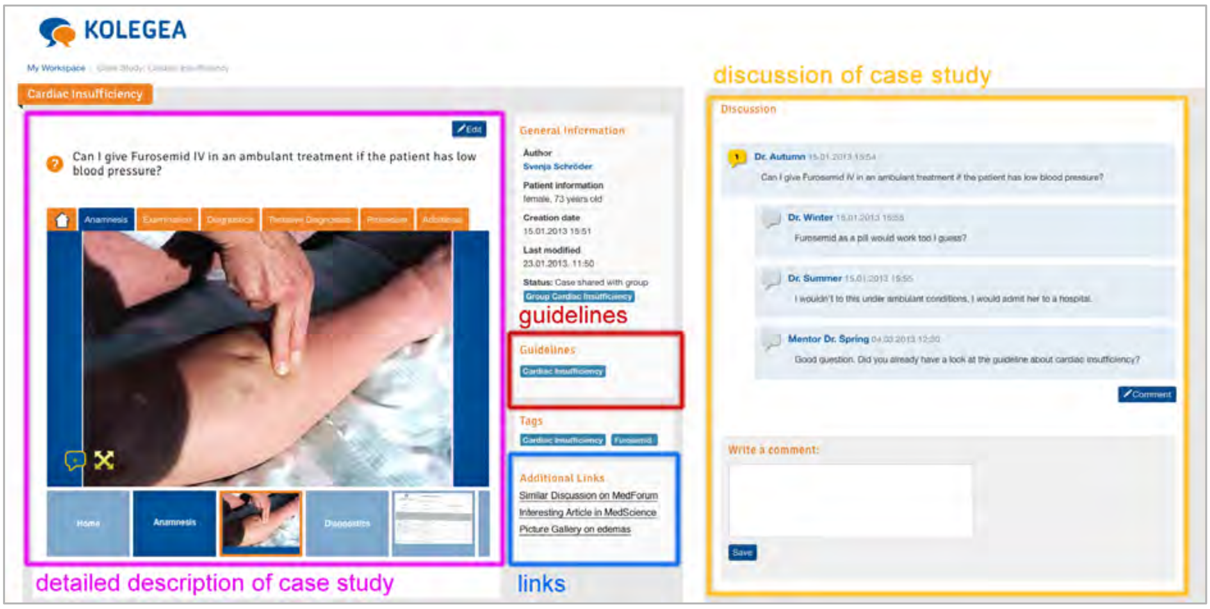

Figure 3. Portal prototype with medical description (left) and discussion (right).

Discussion and Prospects

We have introduced our approach as well as a first prototype of a community portal for supporting occupational exchange and collaborative learning of doctors in specialty training for becoming general practitioners. Our approach is supported by an analysis of the target group, which considers the opinions of trainees (bottom up), as well as trainers and representatives of medical associations (top down). Exposition of our prototypes to the target group generated positive feedback, but also indicated the necessity of training (time) to use it. We are currently acquiring training institutions and especially GPs who are willing to support their trainees in using our platform. Furthermore, we are conducting usability tests with the target group, but also with usability experts to further enhance our tools for the pilot operation phase, which will start in June 2013.

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Volume 2

Panel Papers

From Research Instruments to Classroom Assessments: A Call for Tools to Assist Teacher Assessment of Collaborative Learning

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Abstract: When asked about their experiences with collaborative learning, students typically mention (a) unequal participation by students—up to free-riding, and (b) dissatisfaction with the assessment of collaborative learning. In fact, as inequality of participation increases – especially when there is a free-rider in a group – the call for diversified assessment intensifies. The topic of classroom assessment has remained implicit in wide areas of research on (CS)CL. More specifically, the issue as to how we can support teachers and students in both monitoring and assessment of collaborative learning processes and products has hardly been addressed systematically. This panel brings together researchers from the (CS)CL community to discuss and explore how research instruments can be transformed for classroom assessment purposes – including the role of technology – and what we as (CS)CL community could offer to teachers and students alike.

Assessment and Its Purpose

Assessment is the process whereby information on a students' performance is collected and interpreted. However, what are considered relevant outcomes is governed by their (a) operationalization and (b) subsequent measurement. The assessment of (computer-supported) collaborative learning (CS)CL) is directly shaped by what is measured – yet it also contains a statement on the quality of CL in relation to pre-specified criteria.

Assessment criteria, in turn, are shaped by the purpose of assessment. Broadly two purposes are distinguished: summative and formative. Summative assessment (also referred to as 'assessment *of* learning') is decontextualized and individualistic, it is isolated from the learning process, and it takes place only at the end of a course to judge how well a student performed. Summative assessment focuses strongly on the cognitive aspects of learning, and often applies a single performance score. Formative assessment (also referred to as 'assessment *for* learning') is contextualized, an integral part of the learning process, and takes place several times during a course rather than only at the end. Formative assessment focuses on cognitive, social, and motivational aspects of learning, often applies a multi-method approach and it leads to a profile instead of a single score. Although distinguishing both purposes can be useful, it should be kept in mind that the use of assessment information is an issue of interpretation. A further important distinction is the scale at which the assessment is conducted. In so-called 'large-scale assessment', the performances of hundreds up to thousands of students are assessed on carefully designed tasks, for example to determine and compared the effectiveness of school systems in different countries (PISA, TIMMS, PIRLS, etc.). In contrast, 'small-scale assessment' concerns the performance of a small number of students – typically within a single classroom (or several classrooms in a single school) – to determine the students' performance-level as well as indicators for self- group- and teacher-monitoring and need for learning support.

Irrespective of the purpose of an assessment (be it summative, formative, large-scale or small-scale) the operationalization of relevant CL outcomes is crucial to the assessment of CL. More specifically, it is the question what should be assessed, why it should be assessed, by whom, how, and when it should be assessed.

Assessment of Collaborative Learning in the Classroom

In a recent review on assessment of (CS)CL, Strijbos (2011) showed that revisiting the approaches developed in the 1970s and 1980s is highly insightful for understanding the current CL assessment practices. Slavin (1996) achieved individual accountability through reward interdependence – or more precisely – summative assessment using tests or quizzes. In fact, common to all approaches developed in that era (e.g., Jigsaw, STAD, Complex Instruction, Learning Together, Group Investigation) is that achievement is the principal outcome variable, and typically measured in terms of 'scores' on (standardized) individual tests or quizzes.

Although assessment of CL gained attention in the past decade in face-to-face and online CL contexts, it is currently still (a) mostly summative, (b) designed and conducted by the teacher, (c) consists of individual tasks (i.e., tests, quizzes, essays, etc.), a group task with each student receiving the same grade or a combination of group and individual tasks, and (d) nearly exclusively focused on cognitive outcomes. Especially group grades and/or a mix of group and individual tasks can be problematic. Despite their appeal for efficiency, Kagan (1995) argues that group grades should never be used because: (a) they violate individual accountability and invite free-riding or that the most able group member conducts most (or all) of the work, (b) an individual student typically has little influence on group formation and due to the coincidental presence of high or low achieving students or a free-rider, a group grade over- or underspecifies an individual's competence, (c) low- and medium-ability students generally profit more from group grades than their high-ability counterparts, and (d) unsatisfactory experiences with group grades often result in a reluctance for CL among students.

A group task combined (or supplemented) with one or more individual tasks becomes problematic when a grade consists of the average with a weighting factor applied. In these cases the individual tasks are used to 'correct' group grades for potential social loafing and free-riding, assuming that performance on individual tasks reflects that individuals' contribution to the group task, and validly compensates for a possible lack of individual effort and/or quality of contributions. Moreover, the approaches to such weighting vary and no clear guidelines exist. In fact, the percentage of the final grade contributed by the group task and individual tasks can each range from 10 to 90%. If the group grade is only 10% of the final grade then CL is devalued (Boud, Cohen, & Sampson, 1999), whereas if the group grade makes up 90% of the final grade free-riding is invited.

At present, assessment of CL is typically conducted after the collaboration and disconnected from the collaborative setting (i.e., a lack of 'constructive alignment' exists). Instead, processes and outcomes associated with CL should feature in assessment of CL. Moreover, assessment of CL contexts is predominantly focused on cognitive outcomes (achievement), and not so much on social and motivational outcomes. On the basis of the literature review on assessment of CL, Strijbos (2011) formulated three needs for assessment of CL: assessment of the individual and group-level, assessment of transformation over time – before, during and after CL, and assessment of multiple concurrent processes and outcomes (cognitive, social and motivational).

From Research Instruments to Classroom Assessment

Over the past decades the (CS)CL research community has developed and applied a wide variety of research instruments and analysis methods to uncover and understand collaborative learning processes and products (see the special issue edited by Strijbos & Fischer, 2007), ranging from Social Network Analysis (SNA), content analysis, conversation analysis, interviews, questionnaires, rating scales, log-files, scripts, roles, etc. Whereas these instruments have been pivotal for the advancement of the (CS)CL research community and our understanding of (CS)CL processes and products, the instruments largely remained tools for researchers. As (CS)CL research matures a natural transition would be to extend and/or adapt these tools for use by teachers and students for classroom assessment and monitoring purposes. Some examples of assessment methods that have been used in the context of (CS)CL are (web-based) peer assessment (PA) and portfolio assessment.

In assessment research, PA of group work has been investigated since the 1990s. Most of these studies involve the application of PA to convert a group grade to individual grades (Lejk & Wyvill, 2001). However, apart from the product (or achievement) group members' contribution to the collaborative process can be assessed (Prins, Sluijsmans, Kirschner, & Strijbos, 2005), as well as social aspects like interpersonal relations (Phielix, Prins, & Kirschner, 2010). The rapid development in the past decade of computer supported and web-based PA systems signifies that PA is an attractive approach to assess CL. An example of student portfolio assessment of their own CL processes and products – combined with log-file data – is the research by Lee, Chan and van Aalst (2006). They applied the built-in Analytic ToolKit (ATK: component of the Knowledge Forum© environment) in combination with student portfolios to assess the knowledge building discourse within a community of learners. Finally, Meier, Spada and Rummel (2007) developed a rating format for an overall assessment of the quality of CL and they are to date the only approach to explicitly include a motivational component as part of assessing the quality of CL.

Although the literature on (CS)CL, PA and portfolio assessment shows many promising directions for the assessment of CL, the major omissions are that (a) there is no generic set of agreed-upon CL indicators that can be used for assessment of CL, (b) the availability of teacher and student tools for monitoring and assessment of CL processes and products is limited (Gress, Fior, Hadwin, & Winne, 2010), (c) if available, the information collected by these tools (e.g., most systems collect some type of log-file data) is commonly not applied for teacher and student assessment of CL, and (d) actual teacher practices of CL assessment are sporadically investigated. In relation to assessment of CL there are some practitioner-oriented initiatives to apply complex coding schemes developed for (CS)CL research to assessment of CL (e.g., Crisp, 2007), which clearly signifies a need for transformation of research instruments into easy accessible and manageable assessment tools for teachers and students. Technology can potentially support the teacher with the assessment of collaborative learning – and specifically strides that have been made in the (CS)CL community with, for example, automated analysis and visualization – could assist teachers with this demanding task.

Panel Format and Interactivity

The panel will focus specifically on small-scale classroom assessment. To achieve a balanced representation of issues and the (CS)CL community, panelists were invited from different geographical regions, with a variety in research topics and perspectives on assessment of CL. Some of the themes to be covered are:

- How to address the practice of group grades in classrooms?
- What aspects of collaborative learning can (and ought to be) assessed?
- Does a mix of graded individual and group assignments make sense?
- How can technology assist teachers in the process of grading collaborative learning?
- What are the benefits/ drawbacks of automated assessment in a classroom context?
- How can we use artifacts/products by groups in classroom contexts to assess a group's learning?

The focus of this panel on small-scale classroom assessment and support for teacher and student monitoring and assessment, covers the topic of CL assessment in tandem with the invited panel organized by Gijsbert Erkens, Chee-Kit Looi, and Sadhana Puntambekar. Their panel focuses on large-scale assessment within the context of international PISA studies and is entitled "Can we measure collaborative skills through human-agent collaboration" (Confirmed panelists are: Chee-Kit Looi, Pierre Dillenbourg, Patrick Griffin, Jim Pellegrino and a representative of the OECD).

Interactivity

The panelists will be grouped in pairs, who will then individually prepare and briefly present their (contrasting) perspective(s) to (one or more) of the themes. The audience will be involved both prior and during the panel discussion via the web-based system "Understood It", where we aim to collect opinions in advance and during the conference. Audience responses will be monitored and projected on a separate presentation screen during the panel discussion. The input of the audience will be used to prioritize themes for the panel discussion.

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Promises and Perils of Using Digital Tools in Informal Science Learning Environments: Design Considerations for Learning

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Abstract: In this panel, six informal science projects discuss how instructional and technological design elements interact with the unique affordances and constraints of informal environments to impact learning. A central goal of the panel is to engage colleagues in examples that illustrate design decisions that inform research trajectories to move the field of CSCL forward in the design of informal learning environments.

Panel Topic

The National Research Council report on learning science in informal environments (NRC, 2009) examines the potential that non-school settings such as zoos and museums, have for engaging large portions of the population in scientific investigation. These experiences often stand in contrast to those typically found in traditional school science. The voluntary nature of participation often satisfies a sense of identity; fulfills individual social, emotional, and intellectual needs; and provides a degree of personal control over learning activities (Falk & Dierking, 2000). As informal activities have increasingly included digital tools, the NRC report also calls for more research on how digital platforms improve the learning experience. However, before we can study any impacts on learning, we need to construct good interventions and investigate how the designs do or do not optimally engage learners. In this panel discussion, we include six informal science projects that have gone through this critical design phase. We use the lens of design research due to its emphasis on a wide range of variables that may have contextual importance (Confrey, 2006) and the grounded-in-practice nature of the research, which increases the likelihood that interventions will be successful in the real world (Bielaczyc & Collins, 2007). An additional goal of the panel is to engage colleagues in examples of research that Puntambekar and Sandoval (2009) suggest can illustrate design decisions that inform research trajectories to move the CSCL field forward in the design of informal learning environments.

Panel Focus and Format

Panel contributors will focus on how instructional and technological design elements interact with the unique affordances and constraints of informal environments and will address factors that impact learning. Each presentation will introduce the context and learning goals, describe the design elements of the technology and associated activity, and provide an analysis of the design considerations in light of improving the learning goals. The panel incorporates perspectives from several different informal settings and a variety of digital tools. As we expect the topic of the panel to have a high degree of saliency in the CSCL community and would like to learn from other design researchers who conduct similar research in informal science environments, we would like to leave ample room for interactive dialogue with panel attendees. Thus, panelists will speak for 12 minutes about their project and 30 minutes will be devoted to community exchange. The five panel projects are listed below.

Doing Augmented Reality and Knowledge-Building in a Science Museum: Formalizing an Informal Learning Experience

Susan Yoon, University of Pennsylvania & Karen Elinich, The Franklin Institute Science Museum

The project *Augmented Reality for Interpretive and Experiential Learning (ARIEL)*, seeks to create digital augmentations of science museum devices that provide hidden information to visitors to develop deeper understanding of scientific phenomenon. In this presentation, we will report on a series of quasi-experimental studies in which increasing scaffolds were used in different conditions to support learning (Yoon et al., 2012). Building on the success of knowledge-building communities in formal classrooms, several conditions were constructed to encourage increased peer-to-peer collaboration, access to community knowledge and greater abstractions from interacting with the device. Results showed that students in the knowledge-building condition were better able to theorize about the scientific phenomena than students in other conditions. They demonstrated greater time on task, and discussed ideas with others in their group in more goal directed, intentional ways. However, in observations of device interactions, students in the knowledge-building conditions also behaved in ways that were more like in-school behaviors, less playful, inquisitive, and self-directed—which are hallmark characteristics of learning and participation that make informal environments unique and engaging. We discuss the trade-offs of what we have termed formalizing an informal learning experience and implications for structuring learning for deeper understanding.

Contextual Fit between Formal and Informal Contexts for Middle School Science Inquiry

Chris Quintana, Wan-Tzu Lo, & Shannon Schmoll, University of Michigan

Our *Zydeco* project is exploring the coordinated, integrated use of mobile devices (e.g., smartphones and tablets), web applications, and the cloud to support middle school science practices across formal classroom and informal out-of-class (e.g., museums and parks) contexts (Quintana, 2012). Zydeco helps students plan their inquiry in classrooms, collect different data artifacts (e.g., photos, videos, audios and texts) outside the classroom, and analyze those artifacts to build a scientific explanation, thus framing an activity structure that integrates different contexts into a larger educational setting. As we develop projects with middle school teachers and museum educators, we are identifying different issues when trying to create a more cohesive fit between formal and informal contexts: (1) *resource fit*, or the challenge teachers face in understanding what resources are available in out-of-class contexts and how those resources connect to their curricula and current science standards, (2) *supportive fit*, or the scaffolding features that need to be developed and embedded in the mobile tools, museum exhibits, and other resources to support students with the reflective and analytic activity needed for sensemaking with respect to their science questions and goals, and (3) *cultural fit*, or the potential mismatch between the goals of structured and free-choice contexts, the way these different goals impact exploratory activity, and the anxieties about technology that arise in many informal contexts.

Embodying Data: Using Performative Embodied Interaction Experiences to Engage Visitors in Data Interpretation in Zoos and Museums

Leilah Lyons, UIC & the New York Hall of Science

Informal Science Institutions (ISIs) have traditionally played an educational role by either hosting the curated *products* of scientific endeavor (e.g., pottery, animals) or providing access to the *processes* of scientific inquiry via hands-on exhibits (e.g., light tables, heat cameras). What does it mean for ILIs now that the *products* of science have evolved to be large data sets, and the *processes* involve the interpretation of those data sets? In two projects we explored the use of embodied interaction as a low-threshold, personalized entry point for data interpretation. One, with the Brookfield Zoo, asks visitors to role-play as polar bears in a game that plots their effort expenditures on a graph, co-constructing a visualized *product* illustrating the accelerating impact of climate change (Lyons et al., 2012). In a second project with the Jane Addams Hull House Museum and the New York Hall of Science, we allow visitors to "embody" subsets of georeferenced data, animating them with bodily motions, to transform inter- and intra-subset comparisons into an active social *process* of data interpretation. In the former case, we find that participation leads to better learning, but audiences also need opportunities to learn. In the latter, we find that visitors generate good questions about the data, but need further support (with representational fluency or background knowledge, or both) to then answer those questions. We are now exploring how docents might be incorporated dynamic digital exhibits to address these challenges.

Race Against Time: Leveraging an Augmented Reality Game to Engage Students with Global Climate Change Issues in a Zoo Setting

Judy Perry & Eric Klopfer, MIT Scheller Teacher Education Program

For the past decade, MIT's Scheller Teacher Education Program (STEP) Lab has been developing augmented reality (AR) games as well as toolkits to make AR games. These location-based AR experiences utilize the player's mobile device to provide a digital layer of information enhancing the real-world experience. MIT and the Columbus Zoo and Aquarium (Columbus, OH) partnered to develop new AR games to enhance visitor experiences by engaging players with the Zoo's physical space employing a narrative, game-like experience. In Fall 2011, a mixed methods study was conducted comparing the experiences between (a) students visiting the Columbus Zoo playing an AR game, and (b) students freely exploring the same physical areas of the Zoo. Findings suggest that playing the AR game impacted students' beliefs and ideas about global climate change (the theme of the AR game) more than the control group. Observations of students also provide data comparing the movement, discussion and gaze patterns between AR and control students. Findings here also suggest trade-offs in terms of students' time looking at animals and exhibits, versus time engaging with AR game elements.

Harnessing Imagination in Fostering Scientific Identity in Curated Games

Scot Osterweil, MIT Education Arcade

In collaboration with the Smithsonian Institution, the MIT Education Arcade developed a new form of informal activity, the *Curated Game*. Staged as an eight-week long event, played on-line by middle-schoolers across the country, the first curated game, titled *Vanished*, engaged players in a mystery quest that resulted in thousands of players collaborating on a nested series of scientific investigations. In the course of the game players investigated topics such as cryptography, geology, forensic anthropology, archaeology and climatology. In the process they participated in data collection, investigations in museums and science centers, hypothesis formation, scientific argumentation and calibration. They collaborated with fellow players while being mentored daily by MIT undergraduates on-line, and weekly by Smithsonian Scientists through videoconferences. The goal of the game was not to develop expertise in any particular scientific domain, but rather to expose players to scientific processes and to increase student identity with scientists and scientific practice. Analysis of the thousands of forum posts generated in the game show solid evidence of this effect, as well as new findings about the role of imagination in fostering serious scientific thinking and disciplined scientific practice. We will discuss these findings both in the context of the completed game *Vanished*, and how they are influencing the design of our follow-on curated game project devoted to engineering practice, *Gadgets*.

Supporting Body Cueing with Immersive Technology to Promote Science Learning in Informal Spaces

Robb Lindgren, Michael Tscholl, Eileen Smith, and J. Michael Moshell, University of Central Florida

Informal learning frequently occurs in spacious environments that afford physical exploration and engaging one's body in the process of conceptual development. The *MEteor* project leverages these features of informal learning spaces to build middle school students' intuitions about physics in an interactive mixed reality simulation of planetary astronomy (Lindgren, Aakre, & Moshell, 2012). Working with two Science Centers in Central Florida we have designed the room-sized immersive simulation game to support a type of embodied interaction where a learner moves in specific ways as a means of understanding the functionality of a target domain. In the case of *MEteor*, a learner uses their body to enact predictions of an asteroid's trajectory as it encounters planets and other entities in space. Different configurations of audio, visual, and physical cues guide learner movements and scaffold their understanding of important physics concepts such as Newton's and Kepler's laws. *MEteor* participants have shown greater engagement, self-efficacy, and more adaptive knowledge structures compared to learners who use a desktop computer version of the same simulation. We are currently investigating the effects of *social feedback* in *MEteo*r—harnessing the input of visitors "on the sidelines" who assist in guiding participant movements.

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Volume 2

Poster Papers

A Simulation-Based Approach for Increasing Women in Engineering

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Abstract: Institutions have historically struggled with retaining women in engineering. Using epistemic frames as a theoretical framework, we propose that more women would remain in the field if they had authentic engineering experiences. To test this hypothesis, we implemented an epistemic game, Nephrotex. Our controlled study indicated that (1) Nephrotex women developed positive associations and (2) focused on engineering design. Further study is needed to determine if this positive design experience leads to persistence in engineering.

Introduction/Theory

Educational institutions at all levels have historically struggled with motivating and retaining women in engineering. The single biggest drop in engineering enrollment occurs between the freshmen and sophomore year (Atkinson & Mayo, 2011). First year undergraduate courses thus play a pivotal role in a student's decision to major in engineering, but these courses aren't retaining women. Recent studies show that women are generally more interested in STEM when it involves teamwork, collaboration, and professionalism, and social impact (Thom, Pickering, & Thompson, 2002; Zastavker, Y Ong & Page, 2006).

An alternative hypothesis is that some students opt out of engineering because of the basic math and science courses that are the focus of the first year curriculum (Lumsdaine & Lumsdaine, 1995). In this view, more first year students would remain in the field if they had authentic experiences of the engineering profession such as engineering design—the most central aspect of the profession (Dym, Agogino, Eris, Frey, & Leifer, 2005) in the form of a professional practicum.

Shaffer (Shaffer, 2007) has characterized the learning that takes place in practica in terms of an epistemic frame. Epistemic frame theory suggests that every profession has unique collections of skills, knowledge, identities, values, and epistemology that construct an epistemic frame. Developing an epistemic frame means making connections between these elements. Thus, the goal of a professional practicum is to build a professional epistemic frame—to develop the ability to think like a professional. However, first year students do not have many opportunities to participate in practica.

One approach to this problem are epistemic games—computer simulations of professional workplaces where novices can solve real-world problems without needing to first master basic domain content. The complex knowledge and skills that students do not yet have are embedded in the tools that novices use in the simulation (Bagley & Shaffer, 2009). In this study, we designed and tested an epistemic game for engineering called Nephrotex. This study asks: Did attitudes towards engineering careers change more positively among women who played Nephrotex? Were students who made more connections with engineering design more motivated to continue in engineering than those who made more connections with collaboration and professionalism?

Methods

In Fall 2010, 120 students enrolled in an introductory engineering course. In total, 45 students (13 female, 32 male; treatment group) participated in Nephrotex. The remaining 75 students (24 female, 51 male; control group) participated in team-based research projects.

Two sources of data were collected for this analysis of Nephrotex: (1) students' pre and post survey responses and (2) students' discourse in the chat program. We conducted a PCA on survey responses. The mean scores on the significant component for women and men students were calculated, and t-tests were used to compare the percentage of students that had positive gains from pre to post survey.

We coded the discourse using codes using epistemic frame theory as a guide for professional practices. We used Epistemic Discourse Coding, an automated coding process that has been validated by comparing hand-coded utterances by human coders to the automated coding system. Cohen's kappa scores were between .80 and .98 between the automated system and human coders (D'Angelo et al., 2011). We used Epistemic Network Analysis (ENA) on the coded discourse. This analysis tool measures relationships between epistemic frame elements by quantifying the co-occurrences of those elements in discourse (Shaffer & Chesler, 2009). Here we used ENA to measure students' development of connections made between skills, knowledge, identity, values, and epistemology.

Results

The percentage of women in Nephrotex that had a positive change in mean scores (M = 72%, SD= 19%) were significantly larger than the percentage of women in the control group that had a positive change in mean scores (M = 35%, SD = 22%, $p < .05$) (figure 1).

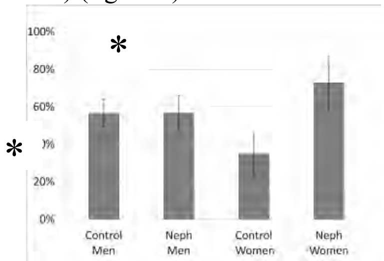

Figure 1. Percentage of students that had a positive increase in mean scores from pre to post on *positive view of engineering careers.* (Mean ± Standard Error, * $p<.05$)

ENA component 1 (ENA1) and ENA component 2 (ENA2) were significant. Items that loaded negatively on ENA 2 are related to data analysis and professionalism, and items that loaded positively on ENA 2 are related to engineering design. Students in Nephrotex who made more connections between the skills, knowledge, and epistemology of engineering design and other engineering frame elements showed positive change in *positive view of engineering careers* from pre to post survey. In other words, ENA2 scores significantly predicted positive view of engineering post scores when controlling for pre scores ($\beta = 1.789$, $p < .05$, $R^2 = .411$). Thus, results from this study show that women who participated in Nephrotex viewed a career in engineering more positively than women in the control group, and these changes were associated with engineering design activities in the internship.

Discussion

The question we address in this study is whether these women showed an increase in their positive associations with engineering after engaging in authentic engineering design, developing an engineering epistemic frame, and as a result having a positive view of engineering. This is in contrast with a more traditional hypothesis, enacted in this study's control condition and in many current first year undergraduate courses of collaboration and social value leading to a positive view of engineering.

The results above suggest that women in the Nephrotex condition who focused on design had a more positive view of engineering than women in the control group. We therefore propose the *epistemic persistence hypothesis* (figure 2). Further study is needed to test the epistemic persistence hypothesis for first year undergraduate women.

Figure 2. Epistemic persistence hypothesis.

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Teenagers re-design a collaborative mobile app to kindle motivation for learning about energy consumption

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Abstract: Previous work informed the design of a collaborative mobile application to support learning about personal energy consumption. In this study teenagers used and re-designed the application. Collaboration with other members of society emerged as a potentially significant motivating factor. Findings also indicate participants were not clear how energy issues will affect them, which might impact on motivation to learn. The work contributes to our understanding of how to design collaborative learning technologies about energy consumption that are motivating to teenagers.

Introduction

Little is known about teenagers' conceptions of the issues around energy consumption. Some evidence suggests that, although teenagers show awareness of energy problems and report concerns about the future, they lack awareness of their personal energy consumption and also lack motivation to learn how it contributes to global issues (Avramides, Craft, Luckin and Read, 2012). Studies with adults also suggest there is a lack of awareness regarding the connection between environmental issues that arise from energy consumption and individual consumer choices (Lorenzoni, Nicholson-Cole and Whitmarsh, 2007). It is, therefore, important to highlight to teenagers how individual choices form a pattern of personal energy consumption over time, and relate to larger scale energy issues. Collaborative learning experiences might be effective in drawing this connection between individual and global, and support learners in understanding how their individual behaviour is part of a collective pattern of behaviour. Technology can effectively support collaborative learning, particularly when the collaborative element is embedded in the design (Lewis, Pea and Rosen, 2010). Building on previous findings (Avramides, Craft, Luckin and Read, 2012), we designed a prototype mobile application to support teenagers learn about their personal energy consumption. The application was designed to support a collaborative learning experience. The focus of the present study was on motivation: what design would motivate teenagers to learn about energy.

Framework for Learner Centred Design

A methodology that identifies the multiple influences upon teenage decisions and behaviours, and that draws connections between their circumstances, motivations, attitudes and knowledge is required for the design and use of technology to support learning about energy. This methodology needs to be participatory in order to ensure that a clear and accurate understanding of the complex influences within their personal contexts is integrated within any resultant design. The Ecology of Resources design framework (EoR, Luckin, 2010) offers a process for working with participants that models and takes account of their context.

The EoR provides a method through which we first identify the world resources available to the learner and the processes and relationships that shape the learner's access to these. We also build an understanding of the learner and what they bring to the learning experience: their personal resources. The EoR also introduces the notion of filters to describe the artefacts that constrain a learner's access to resources, such as rules, regulations or physical boundaries. Having mapped out the learner's context we begin an iterative participatory process of design with the aim of developing technology that facilitates access to appropriate resources at appropriate times during the learning process. The EoR design process offers a *3 Phase structure* through which educators and technologists can develop technologies and technology-rich learning activities that take a learner's wider context into account (see Luckin, 2010 for framework detail).

Study Aims and Research Questions

In this study we focussed on Phase 3 of the EoR (development of scaffolds to support learning). Based on our findings from Phases 1 and 2 we developed a prototype mobile application, as a prompt to engage teenagers in the design process. The participants used and then re-designed the app. The research questions were exploratory. We examined both (1) the participants' use of the prototype application we gave them, and (2) their ideas for re-designing it. The focus of the re-design was on motivation. The lack of motivation to learn about personal energy consumption was a key issue we identified in previous studies. Specifically, we explored what would motivate teenagers to engage in terms of (a) the type of activity, and (b) the type of reward for engaging in the activity.

Participants and procedure

We engaged with two UK schools. In group 1 there were 7 students (aged 14 years old; 4 male) who had recently finished a school project on citizenship and energy consumption. In group 2 there were 6 students (aged 14 years old; all male) who were attending a school that is part of the national Eco school network (www.eco-schools.org.uk/), and taking a class on environmental education. We intentionally recruited participants with awareness of energy issues, as they would be better able to contribute to the design of a learning experience.

We engaged with the participants over 2 sessions one week apart. A *questionnaire* was given to participants before the first session. *Session 1* lasted about 1 hour and introduced the study and app. *Session 2* lasted about 2 hours and involved giving feedback on and re-designing the application to make it more engaging for teenagers to use. The teachers were present in both groups and contributed to prompting the discussion.

App functionality and design

The user can send and receive challenges. In response to a received challenge the user can create a pledge, and specify a date until which the pledge is active. Sent and received challenges, active and expired pledges can be shared with others. The design of the initial mobile application was based on previous research in Phase 1 of the EoR that led to an initial EoR model. The key findings that shaped the design were: a) Most participants did not think about their personal energy consumption, even though they were aware of energy issues at an abstract level. Therefore, we designed the app to prompt them to focus on *personal* energy consumption, b) There was lack of awareness around indirect energy consumption, and the relative energy used by different devices. We also identified the energy consumption that appeared to be the most relevant to teenagers. Therefore, the challenges are created based on a template that targets these specific issues, c) Participants mainly thought of their contribution to saving energy in terms of using less rather than finding alternatives or persuading others. We, therefore, prompted them to consider other options by embedding them in the challenges template, d) The Internet was listed as a main source of information on energy, even though participants appeared to lack the skills and background knowledge to search online for information on energy. We, therefore, added a placeholder for adding a hyperlink for additional information on the challenge.

Findings

We analysed the data in relation to: a) the participants' attitudes and knowledge about energy as expressed in the questionnaire, b) use of the application, and c) ideas on how to re-design the application, including feedback on the prototype app we gave the participants. Due to space limitations, we highlight some findings. As in our previous work, we found that teenagers are not particularly motivated to learn about their energy consumption, even though they report high concern about energy issues. In particular, we found that teenagers do not have a clear idea of how they might be affected. Regarding the use of the prototype application, findings are consistent with our previous work that suggests teenagers lack the skills to find information about energy, even though they are confident that there are sources available to them online. In terms of re-designing the phone application, participants insisted that it must be a game. This is not surprising, but it is interesting to examine their analysis of what elements a game would need to have to make it engaging. A promising idea to motivate teenagers to engage was that of their school benefitting through sponsorship from the effort they put into learning about energy. This also links to their comments about energy saving not being something that is visibly done by others. Connecting teenagers' effort to learn with effort from other people might provide an incentive for them to engage, and a more tangible and immediate result of their actions.

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PROSPECTIVE MATHEMATICS TEACHERS INTERACTING IN ONLINE CHAT CONCERNING THE DEFINITION OF POLYHEDRON

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Abstract: Research that analyze the construction of geometric concepts through interactions on online are scarce. This study focuses on pre-service mathematics teachers (PSMTs) discussing about the definition of polyhedrons. One case study will be discussed. The chat proved to be a scenario that improved reflecting about the definition in three scopes: one in the context of solids, one focused on its elements (faces, vertices and edges) and still another one centered in the number of dimensions.

Introduction

VEL are mediated by different technologies. In VEL individuals can exchange ideas and develop their mathematics concepts, without hierarchy or domination from one participant on another (Çakir et al., 2009). In our VEL one way to exchange ideas is through the use of writing, and learning is understood as forms of participation and changing in discourse (Sfard, 2008). In our study we focus on written online interaction regarding the definition of polyhedrons[1]. Writing about mathematical ideas allows individuals to review, at different moments, their understanding concerning some concepts. Practices that allow PSMTs to develop an understanding about the nature and function of definitions contribute to improve their professional knowledge (e.g., Zazkiz & Leikin, 2008). Assuming defining and conceptualization are important processes in mathematical thinking, we believe that those processes could be improved even in virtual environments, because in VEL reflections could be interchanged in different discursive ways and moments.

Research Context and Data Source

The Gepeticem environment (http://www.gepeticem.ufrrj.br/cursos.php) is structured around a vision of work that breaks with the axiomatic approach and the memorization of formulae in geometry classes. Although we agree with Tanguay and Grenier (2010) about the importance of the proof in the geometry classroom, we decide, at this moment of our study, to construct our VEL based on a situation related to the activities of defining, exploring and experimenting via different sources. The chat proposal was: *See below how four future teachers characterize polyhedron: PSMT 1 (A polyhedron is a three-dimensional geometrical solid, the faces of which are polygons), 2 (A figure of 3 dimensions formed by polygons), 3 (A polyhedron is made of polygonal regions and the space limited by them), and 4 (It is a solid, the surface of which is a finite number of faces (polygons)). Analyze and discuss with your partners the definition of polyhedron expressed by each one.* The proposal was sent to them, by e-mail, 10 minutes before the online chat. The chat takes about 120 minutes (two regular classes of 60 minute each). We used the following procedures for data reduction: chat transcription (a file provided by the platform itself), numbering (in lines) of interactions, removal of lines which contained no ideas related to the concepts we were intent on focusing, re-reading interactions and organizations in turns.

Results

We found that PSMTs interacted in three scopes regarding polyhedron definition: aspects associated with geometric solids in general; aspects focused on the elements (faces, vertices and edges), and reflected focusing on the number of dimensions. At the first moment, we observed the development of the whole interactive process, as is shown in the following sequence over the first 4 minutes of the debate.

Figure 1. Part of the transcription of the online chat.

fmagalhaes (10:18:30) : my answer was incomplete
mary (10:18:59) : taking into account it's a first contact with the concept of polyhedrons I guess the ideas 3 and 4 were the simplest to understand
fmagalhaes (10:19:13) : … they are too formal for the pupils' understanding
thiago (10:19:33) : I've already got 4
erj (10:21:12) : I found the definitions 3 and 4 are more understandable.
thiago (10:21:21) : I guess 3 was a bit complicated
researcher (10:22:06) : what's making 3 more complicated?
rschiaro (10:22:10) : It's a solid, the surface of which is a finite number of faces

At this *first moment*, we tried to have an overview of interactions, the subjects' motivations, their curiosity and the elements that appeared to have caused them some cognitive unbalance. For example, the perceptions about the answers that had initially been presented, familiarity (or lack of it) with the subject, doubts or questioning addressed to the group, and agreements. That is why we consider important to get to know the cognitive group as it constitutes itself in the first place (Stahl, 2006), and, from there, later develop an analysis oriented toward one of the participants. So, at a *second moment*, we randomly chose one PSMT, the first one who entered the chat to interact: *erj*.

Figure 2: Focus on a single student.

erj (10:23:13) : I guess when the definition talks about a number of dimensions it gets difficult for the pupils to learn. That's why I like 3 and 4 better erj (10:24:52) : The problem in 1 is the "three-dimensional" erj (10:28:50) : I think a solid, kids already understand better what it is without a definition that's too formal erj (10:36:06) : One more thing, ... I think we should define a polyhedron without prior citing its elements (faces, vertices and edges) and then identify them later erj (10:45:23) : How about: "A polyhedron is a geometric solid, formed by a finite number of polygonal regions (polygons)

At this analytical moment, what interests us mainly is to identify the movement from individual ideas to collective thinking (*but, wait a minute, hey you guys*) and backwards, as all the participants have a possibility to think and talk, without asking for permission. It is also important to highlight that even selecting just one interlocutor, it is visible that his/her thinking process is constituted and takes into consideration the contributions from his/her pairs. The contribution from erj (10:45:23) shows that the PSMT considered a definition for a polyhedron. Nevertheless, as the chat encourages the collective reflection and a belonging to the group, then he/she has the possibility to analyze the idea together with the group. At a *third moment*, we analyzed PSMT (erj) in the constituted collective group.

Figure 3: Focus on the students as a collective unit.

fmagalhaes (10:19:13) : … they are too formal for the pupils' understanding thiago (10:19:33) : I got 4 erj (10:21:12) : I found the definitions 3 and 4 are more understandable thiago (10:21:21) : I found 3 a bit complicated erj (10:28:50) : I think a solid, kids already understand better what it is without a definition that's too formal

The above interactive process shows us how the answers can be revised (10:18:30), challenged (10:31:05) and caused (10:36:41) within the collective group. Besides, examples are requested (10:37:04) and relations with the PSMT's practice (10:28:50). This individual/collective back and forth movement has to be valued in the processes of initial training of teachers. Finally, at a *fourth moment*, we highlighted words related to the definition of a polyhedron.

Concluding Remarks

We analyzed online PSMT interactions that focused on ways to define polyhedrons. Participants showed they deepened conceptual aspects in three scopes. These approaches are not sequential, hierarchical, nor individual. In order to identify the three scopes, our analysis switched from a global look on the interactions to a focus where we tried to highlight the mathematical ideas that were most explicit in their interactions. Based on the implemented analysis strategies, we verified that the online chat can be an educational space where the ideas of the PSMTs can be challenged and reviewed by the individual within the collective group. Perceptions of previously given answers, familiarity with the subject under discussion, doubts or questionings addressed to the collective group, among others, can be observed in the interactive dynamics. Examples are continuously required and relations with the teacher-to-be practices may emerge.

Endnote

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Enhancing Engagement and Collaborative Learning Skills in Multi-touch Software for UML Diagramming

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Abstract: The use of Multi-touch interfaces for collaborative learning has received significant attention. Their ability to synchronously accommodate multiple users is an advantage in co-located collaborative design tasks. This paper explores the potential of Multi-touch interfaces in collaborative Unified Modeling Language (UML) diagramming by comparing them to a PC-based tool and evaluating the collaborative learning skills and level of physical interaction in both conditions. The results indicate that even though participants conversed more in the PC-based condition, the use of the Multi-touch table increased the level of physical interaction and encouraged "creative conflict" skills amongst the team members.

Introduction

The use of Multi-touch interfaces for collaborative learning has received significant attention, as they can accommodate more than one user at a time. This is particularly useful for learning through large, shared display systems, such as tabletops (Han 2005). Furthermore, the Multi-touch environment provides new opportunities for interaction between humans and computers. This area has been investigated by researchers from several different educational backgrounds, and they have found Multi-touch environments to be useful, as interaction through touch is both intuitive and natural (Ciocca, Olivo et al. 2012; Kolb, Rudner et al. 2012).

To the best of our knowledge, there has been little research to determine the potential of using Multi-touch tables to enhance co-located collaboration in software design using Unified Modeling Language (UML). Object-oriented analysis and design can be a very complex task, as it requires knowledge of requirements analysis, design, and UML. The problem statement is often vague and incomplete, and students require significant experience in order to be successful in analysis. UML is a complex modeling language, and students are commonly confronted by many problems before becoming skilled in it. Furthermore, UML modeling, like other design tasks, is not a well-defined process. There is no single best solution for a problem, and often there are several possible solutions to the same problem. The level of collaboration in Futura (Antle, Bevans et al. 2010) and WebSurface (Tuddenham, Davies et al. 2009) is limited and restricted to simple actions performed by users, such as putting words into the right context, arranging items over tables, and simple click-and-drag actions. However, UML design involves advanced design issues that highlight the need for new methods of collaboration, such as linking nodes and annotation. In this study, the potential of using Multi-touch technology for software design using UML is explored by comparing it with PC-based collaborative software design and examining the collaborative learning skills and physical interaction in both conditions.

The Experiment

Using Multi-touch table for collaborative UML diagramming has not been widely researched. To the best of our knowledge, there is no Multi-touch table based editor for UML diagramming available. Therefore, we have developed a Multi-touch collaborative UML editor named "MT-CollabUML" (Basheri and Burd 2012) to encourage face-to-face collaborative software design. In order to keep a same variable in both Multi-touch table and PC-based conditions, MT-CollabUML tool was used in both settings.

For the purposes of the research sixteen master program students who were studying "Software Engineering for the Internet" were selected. The participants were all familiar with collaboratively designing software using UML and had completed the course. The participants formed eight groups, each consisted of two people. A within-subject experiment was conducted to compare how the participants used PC with how they used Multi-touch table in terms of collaborative design.

Two separate tasks were implemented, each of which involved the creation of UML-State diagrams through a process of planning, discussion, decision making, drawing and reflection. In order to ensure that the tasks were of the same complexity and required the same level of skills, the course tutor was consulted. Counterbalanced measures design was conducted in this experiment to help keep the variability low. For every pair of groups, we gave one group a UML design task and asked them to complete it using the MT-CollabUML tool in PC-based condition (Figure 1). The other group was asked to complete the same task using the MT-CollabUML tool on Multi-touch table condition (Figure 2). Then the groups switched and were asked to complete the second task using PC and Multi-touch conditions. Group member's learning experience and success are influenced by the quality of communication in team discussion (Jarboe 1996). Collaborative learning Skills includes Active Learning, Creative Conflict and Conversation (McManus and Aiken 1995; Jarboe 1996). According to Soller (2001) using Collaborative learning Skills promotes effective collaboration learning. Therefore, the verbal communication among each pair in both conditions were recorded and analyzed to find out if there were differences between conditions in term of type of verbal contribution. Baghaei (2007) and Soller (2001)'s verbal communication categories were used in this study. They include: "Request, Inform, Maintain, Acknowledge, Motivate, Argue, Introduce & Plan, Disagree, Task and Off-Task".


Figure 1: PC-based condition

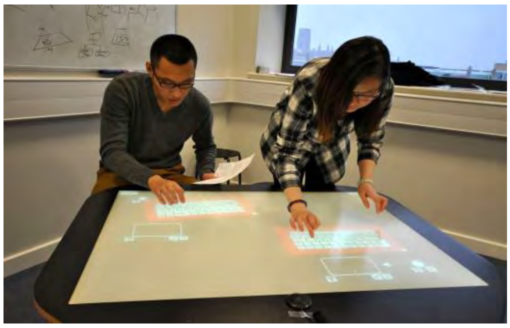
Figure 2: Multi-touch based condition

Conclusion

In this study, the differences in collaborative software design amongst groups of students working in PC-based vs. Multi-touch conditions were investigated. We hypothesised that the Multi-touch table would increase the effectiveness of the collaborative process by enhancing collaboration learning skills and increasing physical interactions amongst team members. The results indicate the benefit of using the Multi-touch MT-CollabUML tool as opposed to the PC-based version in enhancing collaborative software design. The Multi-touch environment increases the amount of physical interactions and subjects' engagements in the design activities. MT-CollabUML tool in the Multi-touch setting encouraged subjects to be engaged in a discursive conversation using "Creative Conflict" skills. More research needs be done in this area to fully explore the advantages and disadvantages of using Multi-touch tables in professional software design.

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Individual Grade Allocation in CSCL Writing Tasks: a Case Study

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Abstract: The research question of this case study was: how does a teacher take semi-automatically generated information on individual contributions to CL into account in grading? To answer this question a teacher assessed students' collaboratively written answers to essay questions and allocated grades based on information on individual contributions. The study shows that these data affect a teacher's grade allocation, and that they are imperative for individual grade allocation.

Introduction

In the assessment of collaborative learning (CL) products, allocating individual grades can be a problematic job for teachers. The problem is often caused by the fact that teachers have no proper indication of what each individual student contributed. In many cases the only solution for teachers is to assign group grades. Group grades however are not the proper answer to this problem. Group grades are not fair, undermine motivation, and violate individual accountability (Kagan, 1995). CSCL allows tracking individual students' contributions through log files. This results in information on exactly what each student contributed to CL. Providing this information to teachers offers a possibility to grade individual students, and avoid group grades. Trentin (2009) and Khandaker and Soh (2010) both used log files from Wiki's to assess individual contributions to written CL products, mainly based on the amount of contributions made.

The focus of the present case study is on how a teacher takes semi-automatically generated information on the quantity and quality of individual contributions to written CL products into account when allocating individual grades. By providing the teacher with different levels of information (a summary of quantitative data, a summary of quantitative and qualitative data, and the entire log files) the following research question is answered: How does a teacher take semi-automatically generated information on individual contributions to CL into account in grading?

Method

Procedure: generation of semi-automated data: The data collection was prepared by collecting collaborative answers to essay questions and information on individual contributions from 22 students at Applied Psychology at the Amsterdam University of Applied Sciences (AUAS). The students were randomly assigned to six groups of either three or four students. Etherpads (web-based collaborative real-time text editors with chat function and a possibility to produce log files) were used in all groups for CSCL. Data on what each student contributed to both chat and the collaborative answer were automatically generated in the Etherpad log files. Students communicated through their Etherpads only, so that all communication was monitored. To encourage students' effort, gift certificates of 7.50 euro for each student in the best group and a single gift certificate of 20 euro for the best individual student were awarded. The student data was then analyzed and prepared manually.

A teacher had composed the essay questions and a scoring scheme for students' answers, and was asked to score each collaborative answer (CA score) to the essay questions for all the groups with this scheme on a 10-point scale. In this assessment the teacher was not aware of the log files, and therefore did not have any information on individual contributions. The teacher also marked in the collaborative answer which text parts she considered insufficient (I), moderate (M), sufficient (S) or good (G).

Charts on individual data were prepared by the researcher. One chart displayed the number of contributions to the chat and the collaborative answer per student, and the amount of words contributed to the chat and the collaborative answer. A second chart displayed which amount of contributions to the chat the researcher had classified as either: 'content related' (dealing with the question's subject), 'coordinative' (contributing to the answering process), or 'remaining' (not contributing to either content or coordination). A third chart displayed per student: the number of times text is deleted and the number of words deleted; and the number of words in the collaborative answer. Data on the quality of individual contributions was presented in two more charts. For this, the data of each student's contributions to the collaborative answer from the log files were matched with the teacher's mark per student (I/M/S/G). This resulted in charts indicating the scored quality of each student's contributions.

Procedure: assessment by the teacher: In three rounds the teacher (35 yrs, female), who had been teaching for 5 years at AUAS, was provided with the collaborative answers, and data on individual contributions. She was asked to allocate grades to individual students when she thought suitable. The three rounds consisted of: 1. assessment based on charts with data on the quantity of contributions per student; 2.

assessment based on the entire collaborative process through viewing the log files and the chat; and 3. assessment based on charts with data on the quality of the individual contributions. In all rounds data of the previous rounds were available.

Data collection: Data was collected in semi structured interviews with the teacher. After each round allocated grades were registered and the teacher was asked to explain how she had derived grades based on the sets of semi-automatically generated data on individual contributions, whether the information provided was adequate for allocating individual grades, and whether she could justify the grades to students. The interviews were videotaped, and participation was voluntary.

Data analysis: Changes in grades given by the teacher were analyzed. Her justification of individual grade allocation was analyzed qualitatively.

Results

The teacher adjusted grades from 14 out of 22 students in the final round compared to the CA scores. For 6 students she adjusted grades from six or higher to lower than six. In a real exam this would be the difference between passing or failing a course. The grades allocated by the teacher are found in table 1.

Table 1: Scores on a 10-point scale per student.

	Group 1				Group 2				Group 3			Group 4			Group 5				Group 6			
Student	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*K*	*L*	*M*	*N*	*O*	*P*	*Q*	*R*	*S*	*T*	*U*	*V*
CA score	6				3				7			5			7				7			
Quantity	2	4	6	4	3	3	3	3	7	7	7	5	3	3	7	6	6	6	6	6	9	9
Log files and chat	2	3	6	4	3	3	3	3	7	7	7	5	3	2	7	5	7	6	6	5	7	9
Quality	2	3	6	4	3	3	2	1	5	7	6	5	3	2	7	5	7	6	6	5	7	9

In the grading process the teacher was convinced that individual students could not score higher than the CA score. She also stated that individual grades were derived by subtracting points from the grade for the CA score when students obviously contributed less then peers, or when a good deal of the contributions were rated insufficient. She said she thought information adequate for individual grade allocation and that grades were justifiable. It should be noted that in groups 5 and 6 the teacher received the information on the quality of the individual contributions before she received information from the log files and chat. The teacher stated that viewing the log files and the chats did not give her reasons to allocate new grades compared to the grades based on the information about the quality of the individual contributions. The information on the quantity and quality of the individual contributions, however, she found imperative. The teacher also stated that the plain text round is necessary for assessing the collaborative answer, and determine the quality of text parts.

Discussion and Conclusion

The teacher did take semi-automatically generated information on individual contributions to CL into account in her grade allocation. The teacher did prove to be able to allocate individual grades and felt grades could be justified to students. Whether other teachers can use information on the quantity and quality of individual contributions for individual grade allocation should be studied in future research.

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Towards Group Cognitive Analysis of Collaborative Learning with Eye-Tracking and Brain Imaging Technologies

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Abstract: This paper aims to motivate the need for a group cognitive approach for the multimodal analysis of learning to better account for neural and ocular correlates of collaborative learning. In reference to related work in the emerging fields of two-person neuroscience and dual-eye tracking, the paper argues for the need for moving from a single-mind perspective to a group cognitive perspective where neural and ocular correlates of joint meaning making are investigated in the context of sequentially unfolding social interaction.

Learning spans a continuum across individual and social scales. At the individual level, learning encompasses cognitive and behavioral changes exhibited by an individual as well as neurobiological changes triggered within an organism. At the social level, learning is encapsulated in the dynamics of interaction among collectivities, and embodied in the practices and knowledge artifacts of a community. Such levels of analysis have been of interest to multiple disciplines including cognitive neuroscience, cognitive science, learning sciences, psychology, sociolinguistics and cultural anthropology. However, differences among the conceptual frameworks employed by these disciplines make connecting levels of analysis a challenging task.

CSCL is a growing discipline within learning sciences that treats learning as a fundamentally social phenomenon. A distinctive aspect of the CSCL community is its collective interest in designing and analyzing technologies for supporting learning at both small group and communal levels. Therefore, CSCL environments are perspicuous settings to capture and analyze learning interactions at multiple temporal and social scales (Dyke et al., 2011). The discussions for connecting levels of analysis in CSCL naturally revolve around how one can coordinate findings across the individual, small group and community levels. One particular proposal in that regard involves focusing on the small group unit of analysis as a mediator between individual and communal levels of analysis, which requires close attention to the social mechanisms through which participants organize their interaction by coordinating bodily, representational and linguistic resources (Stahl, 2010).

Recent advances in technology have led to the development of more portable and affordable brain imaging and eye tracking tools, which offer new opportunities to observe the coordination among brain and eye-gaze activity of dyads during joint action. However, with the exception of a few cases, both eye tracking and neuro-imaging studies have traditionally focused on the individual unit of analysis, which often makes it challenging to make sense of the neural and ocular patterns observed during learning experiments. This paper provides a brief overview of some of the key findings of such studies to illustrate how learning related phenomena is studied with the help of these modalities. Then, based on a discussion of some of the limitations of the individualistic approach, the paper argues for the need to move from a single-mind perspective to a group cognitive perspective to better capture and make sense of ocular and neural correlates of learning.

Existing brain imaging methods allow the monitoring of the human brain through changes in electrical potentials (EEG), magnetic fields (MEG) and cerebral blood oxygenation (fMRI, PET, DTI, fNIRS) induced by neural activity. Each imaging modality has pros and cons in terms of the temporal and spatial resolution of the images obtained, the need for invasive interventions, sources of artifacts that hinder the detection of cognitive effects, portability, equipment cost and ecological validity of the circumstances where the images can be obtained. Due to such factors, neuro-imaging modalities have been predominantly deployed in controlled experimental settings to investigate neural correlates of learning at the individual level (Haier et al., 2009). Such studies typically involve longitudinal designs where improved behavioral performance is correlated with functional and anatomical changes observed in the individual's brain. The results point out that the human brain is extremely good at adapting itself in response to cognitive demands originated from the task environment by utilizing its neural resources in an increasingly efficient way as a consequence of learning. Despite individual differences, cortical areas that respond to specific cognitive processes are distributed in a fairly uniform way. In addition to areas that selectively respond to specific kinds of cognitive processes, some brain regions can be shared among multiple types of cognitive tasks. Such empirical insights allow us to develop better theories regarding the functional organization of the brain and the nature of the cognitive processes realized by it.

Individual level analysis in controlled labs has contributed to our understanding of the functional organization of the brain as well as the nature and the limits of its plasticity in important ways. However, some of the most important influences that the brain adapts itself to are of socio-cultural nature, which are systematically eliminated in the lab setting. For instance, acquiring a language and engaging with other individuals fundamentally shape not only the way we think and act in the world, but also the functional organization of the brain (Dehaene, 2009). Such factors have motivated the need for moving beyond the individual unit of analysis in cognitive neuroscience. Hasson et al.'s (2012) fMRI study on brain-to-brain coupling exemplifies this recent analytical shift in the field, where they compared asynchronous scans of a speaker telling an unscripted story and speakers listening to the same story. Hasson et al. found that even though dyads were not engaged in simultaneous conversation, the speaker's and the listeners' brain activities at their language centers got in synch when the listener genuinely followed what had been said in the recorded speech. Recent work employed simultaneous scans of two interlocutors with portable imaging tools such as EEG (Dumas et al., 2012) and fNIRS (Cui et al., 2012), where increasing levels of neural coupling were observed at pre-motor and pre-frontal areas during collaborative tasks such as imitating hand gestures and finger tapping rhythms. Coupling measures such as Granger causality, wavelet coherence and Kuramoto's synchronization model of complex oscillators are used to detect the strength and the temporal course of coupling among dyads induced by collaborative action, albeit in relatively simple tasks due to analytic challenges.

Similar to most brain imaging studies, eye-tracking research has also considered the individual as the primary unit of analysis. In the context of learning sciences, multimedia learning has been one of the most important applications of eye-tracking research. Such studies often control for the content and the pace of instructional materials, measure eye fixations to identify what parts of the interface learners allocate their attention to, and finally relate these measures to learning outcomes to identify which presentation strategies work better. Since fixation sequences by themselves do not reveal what subjects are thinking or whether they are really paying attention, think-aloud protocols are often employed to interpret the fixation sequences. However, learning to see relevant visual structures at a scene and to associate them with appropriate terminology are also socially shaped processes (Goodwin, 1994), so think-aloud alone is not sufficient to study the relation between learning and eye-fixations. Therefore, a similar argument for switching to the small group unit of analysis can be made for the eye-tracking paradigm as well. The decreasing cost of desktop and mobile eye-trackers have made it practical to track the eye gaze of multiple subjects simultaneously while they are collaborating on a shared task (Nussli & Jermann, 2012). The degree of cross-recurrence among fixation sequences of interlocutors provides researchers useful information regarding to what extent the participants can mutually orient to each other and to the objects in their shared scene.

The review of recent studies in brain imaging and eye tracking research indicate that there is an increasing interest in transcending the individual unit of analysis in an effort to better make sense of neural and ocular correlates of learning. Existing studies that employ the dual brain imaging and eye tracking paradigms focus on devising quantitative metrics that reveal the degree of coupling among dyads to predict the quality or effectiveness of collaboration, without necessarily focusing on the micro-level details of the sequential organization of actions/utterances through which dyads achieve joint attention, coordinated action and shared understanding. Employing a group cognitive perspective is necessary to build a unified account of the interrelationships among the socio-cultural, ocular and neural aspects of collaborative learning. Because the participants naturally articulate their reasoning and respond to each other in collaborative settings, small group level of analysis provides a perspicuous setting to investigate the relationship between what participants do together, where they allocate their attention and how their brains respond to the socio-cultural influences. On the one hand, by focusing on the organization of the interaction, one can better make sense of how brain-to-brain coupling is modulated while peers coordinate their actions to achieve shared understanding. On the other hand, insights obtained from eye-tracking and neuro-imaging modalities can shed further light into how collaborative learning shapes an individual's cognitive processes.

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DALITE: Bringing "peer-instruction" online

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Abstract: Approaches such as Peer Instruction (PI) have resulted in improved conceptual understanding. PI engages students in discussion at the conceptual level and focuses their attention on explanation and reflection. The Distributed Active Learning and Interactive Technology Environment (DALITE) is a virtual learning environment, conceived from principles of PI. We report on this design-experiment and the ongoing efforts to improve DALITE's functionality for instructors as well as its impact on student's conceptual learning.

Introduction

Approaches such as Peer Instruction (PI; Mazur, 1997) have resulted in improved conceptual understanding of physics (Crouch & Mazur, 2001). PI engages students in discussion at the conceptual level and focuses on student's deep understanding by requiring them to engage in a form of reciprocal teaching (Palincsar & Brown, 1984) and by explaining and reflecting on their understanding. Specifically, those conceptual understandings that require restructuring of certain beliefs and ideas because they are not consistent with the canonical (i.e., normative) explanations of phenomena – i.e., conceptual change (e.g., diSessa, 2006). Such intentional reflection is believed to facilitate conceptual change (Sinatra & Pintrich, 2003). In doing so, at the deepest levels, PI requires students to compare their understanding to the explanation and arguments put forward by other students. Additionally, it distributes to students the responsibility of arriving at criteria and standards for what is a good explanation or argument, compared to normative ways of thinking within the discipline.

PI has a history of being used extensively in post-secondary lecture halls with hundreds of students and dozens of teaching assistants who facilitate the types of discussions that can arise from diverse answers and points of view. When there is less support, as is the case in smaller classrooms or when students are at home, PI has not been seen as an option. Starting with the premise that the strength of PI, as an instructional approach, is the intellectual engagement described above, the challenge was to recreate these benefits for instances outside of the typical large classroom scenarios. Our solution was to design an online asynchronous system modeled on the PI approach, which also draws on what we know about conceptual change. We call this system the Distributed Active Learning and Interactive Technology Environment (DALITE). In this poster we will address what was learned from the first full implementation of the system, the data collected and how they are guiding the next design iteration. The overarching question guiding this design-experiment (Brown, 1992) is how do we design a system to engage students in meaningful reflection and understanding of the principles and the networks of concepts that are fundamental to understanding science at the post-secondary level.

What is DALITE?

DALITE is an asynchronous virtual environment that engages students in thinking and producing deeper levels of understanding in science. It maintains a social context while scaffolding a variety of cognitive processes including, categorization or sorting, comparison and evaluation, and linking of concepts and principles through knowledge mapping. Throughout, students are encouraged to engage in reflective and metacognitive processes that involve writing their explanations, reviewing their work as well as that of others, and exploring links and connections between concepts. Additionally, it provides support for motivational processes through the feature of showing the work of peers and asking for students to actively contribute to the database. A typical DALITE script can be summarized by the following TARR flow:

- (T)ag question
- (A)nswer question
- (R)ationalize answer
- (R)ethink answer in light of competing answer/rationale combinations

Specifically, students are presented with a multiple-choice question; before answering the questions, students are asked first to choose appropriate concept (T)ags that help to categorize the question. They then proceed to the selection of an (A)nswer and asked to provide a (R)ationale for their answer. At that point they are presented with their answer choice, their rationale, and other possible rationales for this answer choice. This is all juxtaposed with another answer choice, and rationales for that other answer choice for the (R)ethink stage.

If their answer is incorrect, they are presented with rationales for the correct answer as well as their incorrect answer; the aim of this comparison is to present the contrast and cognitive dissonance of traditional PI. If their answer is correct, they are presented with rationales for the correct and the most popular wrong answer; the aim of this comparison is to test for fragile understanding or lucky guessing. Students are then asked to re-choose an answer for the original question: either their original answer, or the other answer that was just presented to them, based on the reading of these rationales. Lastly, they are presented with a normative rationale of an expert, but are not given "the" answer; the aim of this decision being to delay feedback and increase self-regulation of criteria and standards.

Methods

This study uses a design-experiment methodology. In this particular instantiation, DALITE was implemented as a tool to deliver homework assignments (pre-instruction and post-instruction). Participants were first year science majors, ages 17-19, enrolled in one of five sections of an introductory physics course at one of three Anglophone colleges in Quebec. The pretest scores on the standardized physics concept questionnaire, the Force Concept Inventory (FCI), were used to compare between sections. There were five teachers, each taught a different section. All sections used DALITE in addition to regular course homework assignments. Efforts made to maintain equivalences across pedagogical approaches included weekly group meetings between researchers and teachers. The FCI posttests, along with other qualitative measures, were also collected. The process of reiterative improvement is based on the data collected by DALITE's database – answers, rationales and tags.

Results

General results and student feedback are encouraging. However, to address our research question we look closely at three data sets: (1) the frequency and nature of students' change from incorrect to correct answers, (2) the quality of their rationales and peers' rationales, and, (3) the degree to which the selected tags were able to discriminate between correct and incorrect answers. Data set one: shows that when used as a pre-instruction the students were more likely to gain positively from the exercise of reading rationales. When used as post-instruction, there was a smaller impact. Implications for the next iteration: the difficulty level of the questions needs to be more carefully tailored to the timing of the assignment; and, when used as post-instruction students are less willing to change to the correct answers after reading correct rationales. The latter needs further investigation. Data set two: we have begun a content analysis of the rationales, identifying five different categories. Design implications are to sort rationales into categories and build a heuristic that identifies when and if they are used as part of the database. Data set three: the analysis of tags show they are not discriminating sufficiently between correct and incorrect answers. Design implications: involve greater emphasis on the in-class working with the tags including their use in concept mapping activities. This modification is currently being implemented.

Discussion

Overall the PI features of DALITE are promising. However, the data from the first implication have pointed to several important changes for the next iteration. Most important among these related to the tags. Currently the tags reflect concepts and essential features of the problem. Future work will examine the levels of granularity and a possible reconceptualization with a focus on tags representing "interactions" – e.g., elements of a System Interaction Models (SIM) approach (see the work of David E. Pritchard at MIT).

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Promisingness Judgments as Facilitators of Knowledge Building

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Abstract: Knowledge creation depends on pursuit of promising possibilities. This paper reports a case study of a graduate-level course, with promisingness judgments incorporated as an explicit goal of course work. The top-level goal for the course was to have students take collective responsibility for "*the creation of an assessment of collaborative knowledge creation*." This paper presents the pedagogical design of the course, describes technological affordances to support promisingness judgments, and discusses preliminary findings.

Promisingness Judgments in Knowledge Building

Whether it is industrial designers working on a new product, scientists planning the next experiment in a research program, or policy-makers planning social legislation, decisions must be made about the investment of resources and effort in further development of ideas. "Ideas are the easy part," says a high-profile design group (Fahrenheit 212, 2010), noting that ideas are usually in abundant supply. Going from an initial idea to an innovation, however, requires time and effort, and calls for evaluation about the potential fruitfulness of ideas in an uncertain future. Bereiter and Scardamalia (1993) refer to such evaluations as "promisingness judgments" and have argued that they play an essential role in creative expertise. In explaining creative processes, Gardner (1994) also describes the process of identifying promising ideas as bringing out "discrepant elements" and making the richness of select ideas evident. According to prior research, judgments of promisingness pervade creativity and decision-making of all kinds (e.g., de Groot, 1978; Dunbar, 1995).

Knowledge-building communities are characterized by a focus on problem solving that requires knowledge advancement through dynamic intellectual collaboration among community members (Scardamalia & Bereiter, 2003). Community members work within a framework of shared goals where contributions to the community knowledge space produce idea diversity and consequent need to select promising ideas and solution paths. The shared goals that frame the work are themselves emergents of the process, with effectiveness of the chosen solution path dependent on ongoing evaluation of new information and possibilities. Previous research has found promisingness judgments contributing to knowledge advancement in a Grade 3 science context (Chen, Scardamalia, Resendes, Chuy & Bereiter, 2012). This study explores pedagogical and technological designs to support work in a graduate-level knowledge-building course and investigates how promisingness judgments might be incorporated more explicitly to enhance knowledge-building processes.

Method

The study reported is part of a larger program of design research (Collins, Joseph & Bielaczyc, 2004) on promisingness judgments with the goal of developing pedagogical and technological "promisingness" innovations to facilitate Knowledge Building. The goal of this particular case study (Yin, 2011) was to gain greater understanding of the dynamics of promisingness by making the process more explicit to participants and engaging them in a knowledge building enterprise in which the shared goal represented a significant knowledge building challenge for all—including the instructor. The case was a 12-week graduate seminar at the University of Toronto—one professor, 15 graduate students from the faculty of education. Students were from diverse academic and cultural backgrounds, with varied experience and expertise in education.

Design of the Learning Environment

The knowledge-building goal for the course was "*the creation of an assessment of collaborative knowledge creation*." Achieving this goal required students to understand relevant literature and generate novel solutions. Reading and discussion were not focused on individual comprehension of articles but on collective advances in understanding the literature and generating novel solutions.

To facilitate this process the instructor and students subdivided their community knowledge space into seven interlinked areas of specialization: "Intellectual engagement," "Sustained creative work with ideas," "Concept development," "Social dynamics," "Explanatory coherence," "Reflection, metacognition, collective responsibility," and "Epistemic agency." These were further linked to the top-level community space titled "*assessment of collaborative knowledge creation*." Students worked in a select area of specialization; they and the professor were all responsible for reviewing contributions to each area of specialization, achieving coherence, and advancing top-level goals throughout the 12 weeks of the course.

The pedagogical and technological design incorporated promisingness judgments as a central component. The technology, Knowledge Forum (KF, Scardamalia, 2004) was used to support knowledge-building discourse surrounding readings and to enter ideas generated during class discussion. In both the face-to-face and online discussions, an explicit effort was made to connect ideas from the literature, from students' areas of specialization, and to reflect on how advances in areas of specialization contributed to breakthroughs with respect to the top-level goal of creating an assessment of collaborative knowledge creation. To further promote idea improvement, students were encouraged to use a list of expert vocabulary to monitor their understanding of key concepts and to provide constructive criticism of each other's contributions. Most significantly with respect to the current research, a "Promising Ideas" tool was integrated into KF (see Chen, et al., 2012). Students used this to highlight promising ideas in their notes and, if they wished, send them to one of the seven areas of specialization. In this manner, connections were constantly made between the literature, areas of specialization, and the top-level goal, with focus on identifying and refining most promising ideas.

Data were collected over the 12-week term of the course (total 606 KF notes written, 209 promising ideas selected). In this article we focus on promisingness judgments integral to course work and the extent to which they represented quality judgments, as assessed through independent assessments of promising ideas.

Results and Future Work

Temporal analysis showed consistent occurrences of promisingness judgments throughout the course. While some students endeavored to identify promising ideas on a regular basis, others did so during select, intensive periods of work.

To investigate whether judgments of promisingness made by students were of high quality, we rated all notes contributed by students using four different rating scales: idea development, constructive criticism, authoritative source information, and promisingness. We compared quality ratings of "promisingness" between two groups of notes: (a) notes containing no idea selected as promising versus (b) notes with at least one idea selected as promising. An independent sample *t*-test indicated a significant difference between these two groups of notes, $t(109) = -2.48$, $p = .01$. Mean promisingness scores of notes with promising ideas ($M = 4.70$, $SD = 1.68$) was about 0.6 higher than those without promising ideas identified within ($M = 4.11$, $SD = 1.69$). Similar comparisons were conducted on the other three quality ratings. Significant difference for idea development was found ($t(114) = -2.73$, $p < .01$), but not for constructive criticism or authoritative source information. These results indicated that students' promisingness judgments made throughout their work in the course served to focus on ideas independently judged as more promising and with greater idea development.

Future work will focus on tracing the growth of ideas in notes rated as "promising" versus those not selected. We will (a) analyze user actions with the notes (e.g., build on, reference, export to new context); (b) study the evolution of ideas selected as promising compared to a randomly sampled subset not selected, and (c) tell the story of expansion, redirection, and spread of ideas in these different sets. We will further enhance the Promising Ideas tool to keep ideas on a promising course, as well as foster community knowledge—a principle underlying Knowledge Building. This study contributes to a broader program of research of understanding creative processes and exploring possibilities for schools to operate as knowledge-creating organizations.

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Assessing the Participants in CSCL Chat Conversations

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Abstract: In this paper, we present an application that can be used for assessing the contributions of participants to multiple chat conversations (that debate the same topics) according to different criteria, along with the ranking of the conversations considering a list of important concepts to be debated.

Introduction

Chat is one of the favorite environments for Computer Supported Collaborative Learning (CSCL) tasks that require online and synchronous textual interactions among participants (Stahl, 2006). Most of the existing tools for supporting chats are only aiming at facilitating the conversation without offering analysis instruments. One exception is PolyCAFe (Rebedea et al., 2011), a system which analyzes each user contribution and provides abstraction, visualization and feedback services for supporting learners and tutors. In another context, Chiru et al. (2011) start from the idea of topics rhythmicity in the participants' utterances in order to evaluate the chat quality and the personal involvement of each participant.

Still, what we consider to be missing in these systems is the lack of inter-chat comparison, especially when they are discussing the same topics. Thus, there is no easy way to assess all the chats conversations or their participants according to some predefined criteria imposed by the task at hand. To achieve this, we started from the heuristics proposed by Chiru et al. (2011) and developed two different evaluation methods – an intrinsic one considering only one conversation at a moment, and a multi-chat evaluation, that considers the conversation in the context of the whole corpus from which it has been extracted. We consider the importance of repetition expressed by Tannen (1989), not merely a repetition of words, but rather of lexical chains as we consider that all the words in a lexical chain refer to the same concept. Starting from repetition and other qualitative measures for participation in chats, we have proposed a set of heuristics used to assess the contribution of each participant.

Description of the Automatic Assessment

We developed an application for assessing chat conversations of undergraduate students at a Human-Computer-Interaction (HCI) class that were asked to debate about different web-collaboration technologies (forums, blogs, chats, wikis, etc.) in small groups of 5 students. For validating the results of the system, we have used a corpus consisting of 7 conversations ranging from 248 to 524 utterances per conversation, for a total of 2514 utterances. The same data has been used in validating previous systems (Rebedea et al., 2011).

In order to be able to assess the contribution of each participant to the conversation, we started from the heuristics proposed by Chiru et al. (2011), but we also investigated two other heuristics – *participant's knowledge* and *participant's innovation*. We computed *participant's knowledge* as the percent of the concepts introduced by the participant that were semantically connected with the ones imposed for debating (chat, blog, forum, wiki). In order to discriminate them from off-topic content, we used lexical chains built using WordNet (http://wordnet.princeton.edu/). Since these concepts were very specific to the HCI domain, most of the terms do not appear in WordNet with the required senses. Thus, we had to develop a taxonomy of concepts related to each of the conversation topics and we found 76 concepts related to *chat*, 44 related to *blog*, 63 terms for *forum* and 31 for *wiki*.

The second introduced heuristic, *participant's innovation*, was computed as the number of concepts introduced in the conversation by each participant and represented the degree of new information introduced by that person. The computed values for each heuristic have been normalized with respect to minimum and maximum values obtained for each of them. For this task we had two alternatives: one related to a *single chat* and another considering *all the chats* that were used. The first alternative can be used for evaluating the contribution of each participant in a single conversation, while the second can be used for evaluating a person considering also the activity of all the other persons involved in similar conversations from the same corpus.

After that, we combined the quantitative heuristics proposed by Chiru et al. (2011) - number of replies, activity, absence, persistence and repetition - considering that they all characterize the involvement of a participant. Therefore, we computed involvement as the sum of the values obtained for each of the 5 considered heuristics. The final score for each participant was obtained as an average value of *involvement*, *knowledge* and *innovation*.

The application also compares the conversations one to each other in order to decide which one of them has achieved the best results considering the fact that the discussion topics were externally imposed by the tutors.

Analysis and Results

In order to evaluate the quality of the assessment, we asked 4 HCI experts to manually assess the conversations that were part of our corpus (Rebedea et al., 2011). We ended up with 15 reviews: 4 for chat 117, 3 for chat 116, 2 for chats 118, 119 and 120 and a single review for chats 125 and 126. At the same time, we asked the chat participants to rank their colleagues with respect to their activity in the chat. As a third way to evaluate the results of the proposed system and assessment factors, we also considered the scores provided by PolyCAFe.

The overall correlation was lower than expected, having an average correlation of 0.60 with the tutors, 0.66 with PolyCAFe and 0.47 with the students for the single chat analysis and even worse for the newly-proposed multi-chat evaluation – ranging between 0.24 and 0.37. Moreover, we observed that very large values for the standard deviation have been obtained showing that the overall score is not very suitable for assessing the contribution of the participants. These results are also poor when compared to the correlation between tutors-students (average correlation $r = 0.87$, $\sigma = 0.19$), tutors-PolyCAFe ($r = 0.94$, $\sigma = 0.05$) and students-PolyCAFe ($r = 0.85$, $\sigma = 0.16$).

Therefore, we have tried to see which one of the three components of the overall score is responsible for these problems. We have computed the correlation between the scores provided by tutors, students and PolyCAFe with our results for each of the three components: involvement, knowledge and innovation. The correlation with the involvement heuristic proved to be extremely good, $r = 0.90$ with tutors and PolyCAFe and $r = 0.83$ with students in the case of single chat analysis and 0.86, 0.87 and 0.81 in the case of multi-chat analysis. The standard deviations are also good as they have very low values (between 0.10 and 0.16). The innovation heuristic also seemed to be extremely well correlated with the gold standard, obtaining an average correlation of 0.90 with tutors, 0.93 with PolyCAFe and 0.86 with students with $\sigma \leq 0.10$. These results were the same in both cases of the single and multi-chat analysis.

Finally, the correlation between the gold standard and the knowledge heuristic provided us a great surprise: most of the time, our results proved to be anti-correlated with the gold standard. For this heuristic, both the single and multi-chat analysis had the same results: the average was -0.60 with tutors, -0.57 with PolyCAFe and -0.67 with students, while the standard deviation was 0.22.

Considering this strong anti-correlation for this factor, the main problem with our assessment method proved to be the way we considered knowledge in the final score. Moreover, it seems that our current method for assessing the knowledge of a participant was less correlated with the golden standard even if we would have considered the absolute value of the correlation value ($r = 0.60$ compared to $r = 0.90$ for the other two heuristics).

Encouraged by the above finding, we continued with the 5 factors influencing the involvement heuristic in order to identify which are the most important ones and which can be ignored. Starting from the obtained results, we identified another heuristic that was anti-correlated with the gold standard: *Persistence*. Besides this heuristic, we also identified that *Activity* is not well correlated with the manual annotation ($r = 0.37$ $\sigma = 0.51$). In conclusion, from the initial 5 heuristics considered together to characterize the participants' involvement, only 3 actually provide important evidence to motivate their use: Number of replies, Absence and Repetition.

Conclusions

We have shown that the overall score computed by the application is not very reliable especially when compared to other systems. However, when analyzing each component used to compute the overall score, we have found that some of the heuristics perform quite well and that the overall results are affected by only a single factor. The heuristics that proved to work best are innovation and involvement, while the one used for assessing the knowledge of the participants was either poorly designed or poorly interpreted. Maybe the most important result in this paper is the methodology of how to identify which heuristics work best and which are the ones that should be avoided if a combined score should be computed by a given application for assessing CSCL chats or other learning tasks.

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Levels of Articulated Reasoning In Spontaneous Face-To-Face Collaborations and Online Forum Postings Surrounding a Single-Player Physics Game in Public Middle School Classrooms

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Abstract: This poster explores the levels of reasoning articulated in (a) the spontaneous face-to-face collaborations that naturally occurred in classrooms where students were all playing a single-player game designed to support learning of Newtonian mechanics and (b) in online forums that were created for the students to share hints and strategies about each level in the game. Interestingly, levels of articulated reasoning were very low in face-to-face interactions but much higher in the online forums.

Introduction

James Gee distinguishes between the "game" and the "Game" in terms of the "game" involving the piece of software itself and the "Game" involving all of the interactions, collaboration, community, and cognition that surrounds the "game". He and others underscore the affordances for learning in these "Game" communities through both face-to-face as well virtual interactions. Research illustrates, for example, how the collaborative nature of games serves as fertile ground for problem solving (Gee, 2006) and motivating students (Trespalacios, Chamberlin, & Gallagher, 2011), as well as how language amongst players online serves as a conduit for understanding the nature of game activity in online environments (Steinkuehler, 2006) and developing scientific habits of mind in online forums (Steinkuehler & Duncan, 2008). However, less attention has been given to understanding the role of collaboration during game play in schools. Bluemink (2011) explained that two levels of interaction occurred simultaneously during game collaboration: a relational level (e.g., social interactions) and a content level, as well as that the main content of students' discussion during games involve asking, making content statements, and instructing others. Similarly, Hamalainen (2011) identified various types of interaction during game-play, with providing information (e.g., giving advice, reasoning), asking questions, and managing interactions (e.g., planning upcoming game activity) as respectively the three most prevalent. The purpose of the current study involved exploring the levels of reasoning articulated in (a) the spontaneous face-to-face collaborations that naturally occurred in classrooms where students were all playing a single-player game designed to support learning of Newtonian mechanics and (b) in online forums that were created to allow students in each classroom to share hints and strategies about each level in the game.

Methods

Four classes of public middle school students (N=101) played a version of the SURGE game for three class periods each. Every student had an individual laptop. Students chose their own tables and groups on the first day. Up to four students could sit at any one of the square tables arranged around the classroom. The game was introduced on the first day. Students were told that they were welcome to collaborate and that they could also post hints and strategies about each level for other members of their class (or read the hints and strategies about each level posted by member of their class) in online discussion boards that were created for each class.

Each class period, three researchers with video cameras moved throughout the classroom to capture episodes of collaboration that naturally occurred between students. The video of student interaction across three days of game play in four classes were analyzed, along with transcripts of students' online collaborations on the game's forum. Data analysis involved qualitative coding procedures informed by Grounded Theory (Glaser & Strauss, 1967; Strauss & Corbin, 1998). Through open coding, codes for types of collaborations and conceptual level of physics discourse were developed and refined. In the axial-coding stage, all of the class videos and forum transcripts were examined for the codes developed in the first phase and illustrative examples were identified and transcribed. Throughout this iterative process, codes and emergent findings were reviewed in consultation with members of the research team (Charmaz, 2000).

Results

Interestingly, while students collaborated face-to-face constantly, this collaboration generally took the form of requesting or specifying very concrete solutions to individual levels. As the first pie chart to the right shows, 69% of the 251 videotaped collaboration episodes involved this concrete specification as the highest level of articulated reasoning in the episodes (and 2% of episodes were entirely non-verbal but focused on this concrete specification of solutions in the form of either pointing to places on the screen or physically taking over the other student's keyboard without discussion). Concrete reasoning, which involved discussing or sharing reasoning for solving the level without any overt connection to physics ideas, was the highest level of articulated reasoning for 8% of the episodes. Formal reasoning that included some formal physics ideas or terminology (accurate or not) accounted for 6% of the episodes. Formal reasoning that included some reference to Newton's laws (accurate or not) accounted for only 1% of the episodes. As researchers, we were interested in levels of articulated reasoning, but were disappointed by the low levels observed in face-to-face collaborations.

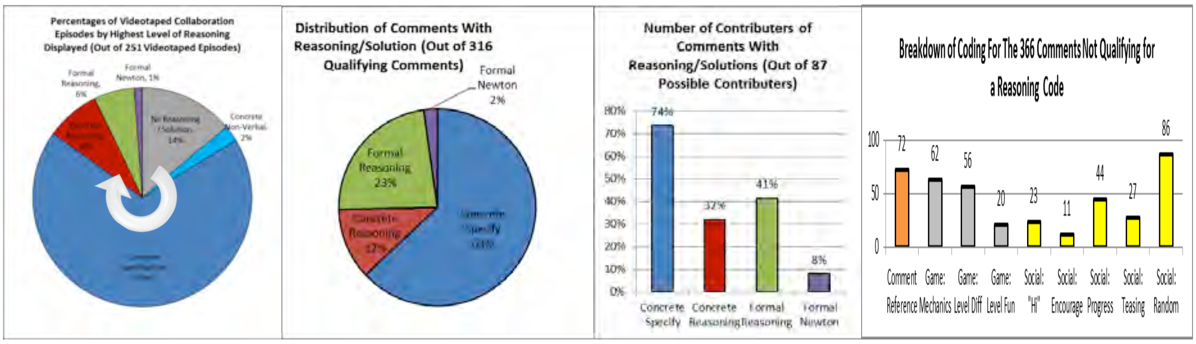

Figure 1. Distribution of Contributions

Students' posts in the online forums, however, displayed much higher levels of articulated reasoning (as shown in the pie chart to the right), which displays the highest level of reasoning in each of the 316 individual comments that articulated a solution or reasoning (out of 682 total comments posted in the online forums). Note that these are individual comments in the online forums whereas the face-to-face episodes included extended exchanges. An important and encouraging discovery was that a broad percentage of the participants contributed these comments (rather than the very small percentage of participants who typically account for most of the high level reasoning in online forums on the Internet, where the vast majority of participants are "lurkers" who do not post at all in comparison to the very tiny percentage of "super users" who account for the vast majority of high quality posts). In our study, we discovered that 87% of the students posted at least one comment in the forums that articulated some reasoning or solution, and that the comments articulating higher levels of reasoning were distributed across students. Even the 8% of comments articulating reasoning in terms of Newton's laws were all posted by different users with no user posting more than one.

We considered this relatively democratic level of contribution in the forums encouraging specifically because it occurred without explicit scaffolding or prompting. We hypothesize that this broad participation may have been facilitated by each class having its own forums such that face-to-face relationships and feedback supported and encouraged forum posting. We are hopeful that through future iterations we can explore the relationships between the comments that articulated reasoning as well as between the comments that did not articulate reasoning or solutions (which are overviewed in the graph above). Between now and the CSCL conference, we intend to conduct pattern analyses of the constellations of comments surrounding comments that articulate high levels of reasoning as well as the constellations of comments that appear to progress less productively. By understanding how the articulation of higher levels of reasoning might be scaffolded in the virtual collaborative space around games for learning in the classroom, we are hoping to learn more about how we might simultaneously support more productive natural face-to-face collaboration without suffering the costs of overscaffolding highlighted in the CSCL literature.

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The Radix Endeavor: Designing A Massively Multiplayer Online Game around Collaborative Problem Solving in STEM

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Abstract: Massively multiplayer online games provide rich contexts for fostering scientific and mathematical thinking and reasoning. We are leveraging these affordances by developing an MMOG, The Radix Endeavor, which integrates STEM practices as core game mechanics. In this poster, we will describe how we are designing the game-play experiences around activities in biology and math content linked to the common core and next generation standards. We hope to generate discussion around (1) designing collaborative problem solving activities (2) using log data to assess players at the individual and group level.

Massively multiplayer online games (MMOGs) provide rich contexts for fostering scientific and mathematical thinking and reasoning. Due to being massive and persistent, the open-ended game play encourages a sustained investment in "systems-based reasoning, model-based reasoning, [and] evaluative epistemology in which knowledge is treated as an open-ended process of evaluation and argument" (Steinkuehler & Duncan, 2008). This reasoning is often done collaboratively (both synchronously and asynchronously) with peers. We are leveraging these affordances by developing an MMOG, The Radix Endeavor, which integrates science, technology, engineering and math (STEM) practices as core game mechanics. In this poster, we will describe how we are designing the game-play experiences around activities in biology and math content linked to the common core and next generation standards. We hope to generate discussion around the types of strategies for (1) designing collaborative problem solving activities (2) using log data to assess players at the individual and group level.

Theoretical Framework

Our work is guided by theories of situated and collaborative learning. From the situative perspective, learning is seen as enculturation supported by social interaction (Brown, Collins, Duguid, 1989; Lave & Wenger, 1991). Engagement and participation in activities are dependent on interaction with other people (Greeno, 1998).

Many terms have been used to describe collaborative learning, such as cooperative learning (Slavin, 1996, Johnson & Johnson 1999), group processes (Webb and Palinscar, 1996), collective cognitive responsibility (Scardamalia 2002), groupwork (Cohen, 1994), and collaboration (Roschelle, 1992). We define collaborative learning as a group of students with distributed expertise sharing cognitive responsibility for a specific task or goal. The emphasis in collaborative learning is on the learning and cognitive advancement of the group. MMOGs, more than any other type of game, rely on collaboration. Not only is this a necessary so-called, "21st century skill;" it is one that is particularly relevant to science as it is practiced by working scientists.

The MMOG: The Radix Endeavor

The Radix Endeavor is a Massively Multiplayer Online Game (MMOG) being developed by The Education Arcade at the Massachusetts Institute of Technology, designed to improve learning and interest in STEM in high school students. The content specifically focuses on statistics, algebra, probability, geometry, ecology, evolution, genetics, and human body systems. Players take on the role of mathematicians and scientists and embark on quests that encourage them to explore and interact with the virtual world through math and science. Players become embedded in a narrative in the world where they encounter a villain who does not believe in the practices of science. Players have to reason about science issues applicable to game characters' everyday lives, refute the unscientific claims of the villain, and make choices based on what they consider to be valid evidence.

Collaboration

A number of tools built into the game will enable players to connect across time and space, communicating about concepts and challenges in the game. For example, "guilds" and "parties" let players easily find where their classmates and friends are in the world, and in-game chat and trading encourage them to discuss their progress and share what they have discovered.

Despite working on quest tasks together, even players on the same quest will see different versions of that task. For example, players may be asked to breed reptiles for different desired traits, or create a scale map of different areas of the city. In this way, players can gift the reptiles they have bred and share their in-progress maps, but doing so in no way "gives away" the answer. Instead they need to use those artifacts as examples and explain the concepts involved in the problem, in order to help their teammates complete the challenge.

Certain quest mechanics will be designed in a way that require two or more players to work together, either to make a large goal more attainable, or by taking on different roles to solve a problem. For example, imagine an ecosystem that has been thrown out of balance: players have noticed that snakes are difficult to find, but they don't know if the problem is related to pollution from the newly built factory, last year's mouse epidemic, or something else entirely. They want to collect population data from this area as well as another similar ecosystem across the island, but it's a daunting task for one player to tag and track every species. So a number of players team up, decide what information they will need to find about each species, and sync up their notebooks. Then as they observe the animals, their data are saved and can be shared with each other. After running some simulations to model the ecosystem, the players come up with a plan to increase the snake population but it requires them to introduce snakes with a certain level of disease resistance, while simultaneously monitoring the changing state of the ecosystem. While this is difficult for an individual, with multiple players one is in charge of breeding more disease-resistant snakes, and one takes on the role of the field ecologist distributing the snakes, while the other uses the simulation tool to keep track of the real-time effects created by their actions. In this way, players are motivated to communicate in order to form a plan as well as to continually provide the team with feedback specific to their own perspective and expertise.


Figure 1. Interface prototype. Figure 2. Geometric map-making prototype.

Data Tracking System

As players interact with the quests, we capture their actions (how they are solving the quest) and whether or not they complete it. We flag actions within quests that may indicate a "misconception" or where to give feedback. For example, if a student breeds the wrong flowers more than three times, feedback is triggered and students receive in-game feedback. This data will allow us to assess individual and group contributions in quests.

Discussion

Early results of prototype testing have been promising. We will continue pilot testing in the winter and spring of 2013 in math and science classrooms in the Northeast. We will present results from our pilots and hope to generate rich discussion around the collaborative tasks and how we are assessing them.

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Systematic Review and Meta-Analysis of STEM Simulations

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Abstract: This paper describes the initial findings of a systematic meta-analysis of the literature of computer simulations related to science, technology, engineering, and mathematics (STEM) learning. Features of the simulations, quality of the research design, and the assessments/instruments used to measure learning are the primary moderating variables of interest. A meta-analysis of 55 research studies of K-12 science education, published between 1991 and 2012, found that on average simulations had a positive effect on science achievement.

Study Overview

This paper presents an overview of the process and initial findings of a systematic review and meta-analysis of the literature of computer simulations related to K-12 science, technology, engineering, and mathematics (STEM) learning topics. Both quantitative and qualitative research studies that examined the effects of simulation in STEM in the K-12 grade range were included in the study. Of these studies, those that reported effect size measures (or the data to calculate effect sizes) were included in the meta-analysis. Important moderating factors related to simulation design, assessment, implementation, and study quality were coded, categorized and analyzed for all of the included articles.

The simulation meta-analysis and review take a systematic look at the research and evidence surrounding learning STEM topics through computer simulations. We are primarily focused on answering three research questions:

(1) What are the advantages of using simulations compared to not using simulations in STEM learning contexts?

(2) What are the advantages of using simulations alongside real-world laboratory or classroom activities compared to using simulations alone?

(3) What types of features or modifications to simulations are most beneficial for learning?

We documented a variety of dependent variables related to these questions, including content-related learning goals, 21st century skill learning goals, and engagement/motivation-related learning goals. Additionally, moderating variables and assessments used to determine learning outcomes were coded and analyzed.

Initial Literature Search

This study focused on computer-based simulations that are neither simple visualizations nor games. Some of these simulations simulated a virtual lab environment (such as a virtual frog dissection), while others represented a more abstract scientific phenomenon (such as structure at the molecular level). All of the simulations had some level of user interactivity, usually in the form of specific inputs that could be changed.

Three databases that were selected: the Education Resources Information Center (ERIC) (http://www.eric.ed.gov/), PsycINFO (http://www.apa.org/psycinfo/), and Scopus (http://www.scopus.com/). These databases were searched for only peer-reviewed journal articles published between 1991 and 2012 (inclusive). The initial search terms included the STEM domains (science, technology, engineering, and mathematics and their subtopics – such as biology and chemistry) and "simulation" or "computer simulation" as primary search terms.

From the database search 2392 abstracts were collected and reviewed by the research team. The abstracts were screened for suitability and exclusion criteria. Most abstracts were excluded for focusing outside of the K-12 grade range, for not including a research study (quantitative, qualitative, or mixed methods), for not being related to STEM content, or for the simulation not being used in a instructional setting. This screening resulted in full-text retrieval of about 200 primary research studies potentially suitable for the analysis.

Article Review and Coding

Through a thorough review of full-text documents, 133 studies were retained for further analysis. Of these, 49 were determined to be research articles including either an experimental or quasi-experimental design. Of those, 9 were determined to contain incomplete or repeated data for this current analysis. The remaining 40 studies yielded 104 effect sizes, 67 of which were in the achievement outcome category, 11 were in the attitudes category, and the remaining 26 that fell into other categories (such as inquiry skills).

The research team coded the articles, with each article being coded by two researchers. The article codes fall into six broad categories: demographic information (location of study, ages of participants, language of instruction); study information (research question, STEM topic); methodological information (research design, group equivalency, attrition); assessment information (source of assessment, type of measures); simulation information (type, collaboration, flexibility, platform); and implementation information (setting, curriculum, time/duration/frequency).

Meta-Analysis Results

Many descriptive characteristics of the comparisons can be reported at this time. Most of the studies were in the domain of science and a few were in mathematics. Follow-up and cross-checking is currently underway to increase the number of mathematics studies. Most of the studies were conducted in either North America or Europe. About 60% of the participants were in high school, while most of the remaining participants were in middle school. Nearly all of the studies were conducted in classrooms. Nearly all of the simulations were either embedded in the classroom curriculum or used as related stand-alone instruction. Most of the simulations could be used collaboratively among students (but not all were implemented this way) and had some structured use (i.e., they were not totally open sandbox environments or highly structured). Assessments used in measuring student outcomes were by and large not technology-based and the vast majority of assessment instruments were researcher-designed.

Seven methodological characteristics were identified, coded and tested to determine if the collection of studies contained systematic bias due to methods employed by primary researchers that might alter the interpretation of results. We concluded that there is no severe bias due to the research practices contained in the collection.

These initial findings indicate that simulations have promise for improving students' learning outcomes in STEM topics. While further analysis needs to be done both with this corpus of studies and the qualitative and pre-experimental studies identified in the literature search, there are many high level findings that can be discussed at this time.

The meta-analysis found, based on 33 science education research studies, that when computer-based interactive simulations were compared to similar instruction without simulations there was a moderate to strong effect in favor of simulations ($g+ = 0.67$, z = 10.07, $p < .000$).

The meta-analysis of 22 additional studies, where simulations were modified to include further enhancements, showed that the enhanced simulations had a moderate effect on student learning when compared to the simulations alone ($g+ = 0.43$, $z = 4.39$, $p < .000$). These enhancements included modifications such as additional scaffolding, feedback, and changing group structures. Scaffolding can be thought of as systematic supports for learners. As this project continues we are examining the details of these learner supports, among other things.

Next Steps and Implications

There is ongoing work on this project to broaden the search criteria in order to ensure that math simulations are included (we only had a handful of math-related studies using the initial search terms). We are also going back and hand checking other review articles to look for important and "landmark" articles that might have been missed. Additionally, we will be coding and reviewing the qualitative studies that met our initial search criteria, in order to help understand why and under what conditions and contexts these learning gains are occurring.

These preliminary results have many implications for science education. They show that simulations can have a significant impact on student learning and are promising tools for improving student achievement in science. Simulations are a key way that students interact with models (an important focus in the new science Framework), especially models based on phenomena that are difficult to observe in the typical classroom setting (due to reasons such as scale, time, safety, or budget limitations). The new K-12 Science Framework (National Research Council, 2012) and the resulting Next Generation Science Standards (NGSS) will be framing the discussion about science education research (and STEM education research more broadly) in the near future.

There are sufficient numbers of studies in this area to allow for detailed further analyses relating to the mechanisms and features that allow for improved learning through simulations. Continued efforts in this area will reveal more information about the assessments used to measure learning. Findings relating to attitudes, inquiry, and reasoning skills are less clear at the moment, due to the low number of studies focusing on these outcomes.

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Designing Interactive Scaffolds to Support Teacher-Led Inquiry of Complex Systems Concepts

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Abstract: This study examined the design of interactive scaffolds to support teacher-led inquiry into complex systems concepts. The goal was to both develop a brief instructional unit with minimal resource requirements, and to examine students' initial understanding of complex systems concepts based on this unit. Early elementary students (aged six to seven) were randomly assigned to six mixed-ability groups of five students (N=30) who participated either in a scaffolded, teacher-led inquiry session with the BeeSign simulation software or a teacher-led book reading session, both centered on honeybees collecting nectar. Statistical analysis of a direct measure and transfer measures indicated that while students in both conditions developed initial understanding of systems related concepts, those in the BeeSign inquiry condition significantly outperformed their peers. Video analyses reveal that designing the simulation around teacher-scaffolded inquiry prompts led to more student articulations of their ideas and opportunities to examine prior misconceptions.

Introduction

Recent research has consistently indicated the value of teaching students to view the world using complex systems related concepts (c.f, Hmelo-Silver & Pfeffer, 2004; Resnick & Wilensky, 1998). The BeeSign project (Danish, 2009; Danish, Peppler, Phelps, & Washington, 2011), a simple computer simulation that depicts honeybees in two different hives collecting nectar has also demonstrated that with robust teacher-scaffolded inquiry, young students were able to explore honeybees collecting nectar from a complex systems perspective (Figure 1 or http://joshuadanish.com/beesign.html). The present study aims to build on this prior work in three ways. First, we aimed to extend the prior examination of elementary students' understanding of complex systems concepts by explicitly examining both direct and transfer measures of learning based on items from the complex systems inventory developed by Goldstone and Day (2010). Second, the goal was to explore the potential for designing a short intervention with minimal resource requirements. This was intended to both vet the possibility for supporting a broader range of teachers in teaching complex systems related concepts, and to begin documenting how a first experience with a system might support student understanding. For that reason, inquiry with the BeeSign software was contrasted with students collectively reading a book about honeybees with their teacher, the manner in which most students would likely encounter this content currently. Finally, to continue exploring the role of teacher scaffolds for supporting student engagement with inquiry into the systems content, these scaffolds were supported by prompts integrated into the BeeSign software, which also supported the first goal by limiting the necessity of prior teacher knowledge of systems concepts, instead building upon their understanding of how to support inquiry more broadly.

Theoretical and Design Framework

The final design is a simple web-page framework designed to scaffold the teacher and students' use of BeeSign (Figure 1). Our design was guided by activity theory, and by the scaffolding framework proposed by Quintana and colleagues (2004). Specifically, activity theory helped us to attend to the relationship between the software (tool), the intended division of labor, and assumed rules for the classroom environment as we identified scaffolds to include.

Figure 1: The BeeSign framework

Methodology

The participants were 30 students (six to seven years old) in a mixed-age classroom (first and second grade) in an elementary school in a small midwestern city. Students were randomly assigned to the BeeSign experimental or the book control condition (n=5, three groups per condition) with an effort to balance groups in terms of teacher-identified ability level. Each condition took approximately the same amount of time (30-40 minutes). All conditions were videotaped for later analysis and students participated in an interview-based post-test to measure their conceptual understanding. These results were coded in terms of accurate mentions of feedback loops, emergence, and iteration. One researcher coded all of the interviews and another coder then coded a randomly selected 30% of the data for inter-rater reliability and achieved an overlap of 90%.

Results

Group results were compared using two *t*-tests with a Bonferroni-adjusted alpha of .025 (.05/2), two-tailed. Students in the BeeSign condition (M = 8.79, SD = 4.66) performed significantly better, $t(16.99) = 9.92$, $p = 0.003$, than the control condition (M = 4.21, SD = 1.85) on the direct measure. The students in the BeeSign condition (M = 3.93, SD =1.82) also performed significantly better, $t(25.26) = .652$, p = 0.012, than students in the control condition (M = 2.21, SD = 1.53) on the transfer measure. To explain the differences in learning gains, we examined video of the classroom activities. We hypothesized that the BeeSign activity promoted a more targeted, rich discussion, providing opportunities for the teacher to guide students through conversations related to how and why the bees behaved, and what the implications of the bee behavior were. The framing of the activity as inquiry also supported the teacher in asking questions to make student thinking visible, and offer opportunities to confront common misconceptions. Video analyses corroborated this hypothesis; the teacher in the BeeSign group typically began the activity by asking students to read what was projected on the whiteboard screen and describe their observations and predictions. He then encouraged them to reflect upon the reasons behind these and solicited multiple competing hypotheses so that they could each be discussed and resolved using the simulation. The teacher frequently challenged the students to analyze and assess their prior predictions. These discussions of specific processes helped students understand the relationship between the bee dance and increased nectar collection.

Discussion

Our design represents a first step in exploring alternative methods for helping schools to integrate cutting edge content into their curriculum in a non-resource-intensive manner. While long-term curricular innovations coupled with professional development are important, the economic reality is that there will be new content that need exploring without a curriculum overhaul. Thus, it is valuable to explore scaffolded design models that leverage existing capabilities to engage teachers and students with this new content with minimal additional cost. Our design was effective precisely because it relied upon the teacher's expertise in leading effective group inquiry. By assuming that the teacher would effectively promote student inquiry, we were able to instead focus upon which questions and aspects of the content to make most visible for the teacher and the students to explore together.

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Hybrid Shmybrid: Using Collaborative Structure to Understand the Relationship Between Virtual and Tangible Elements of a Computational Craft

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Abstract: In this paper we use a case of students' collaborative models to reflect back on the relationship between computational and tangible elements in a design project. The dual nature of the computational craft rather than being interdependent was dichotomized, allowing students to use their prior interests to dictate participation.

Background

In recent years the DIY (Do-It-Yourself) movement has provided exciting new opportunities to open computing to broader audiences by integrating programming with new media production (Kafai & Peppler, 2011). Computational crafts, a hybrid of tangible art and virtual computation, provide young people with new ways to relate to computing through interests and hobbies (Eisenberg, 2003). Studies show these hybrid design technologies can engage young people in multiple disciplines, like art and computer programming or circuit design, especially young people who might not otherwise be interested in or exposed to these disciplines (Rusk et al., 2008). Although studies investigate the benefits of designing with computational crafts, relatively few examine the relationship between collaborative structures and the media themselves. Here we suggest that the way students managed tasks in a collaborative design project highlights potential discrepancies in the fusion of tangible and digital media.

In this study, students' division of roles in collaborative group models demonstrates how compelling it was to pull apart computational and tangible elements of the multi-modal design project. Rather than providing multiple means of entry into design, for instance engaging in programming through a prior interest in crafting, the multi-modality allowed for division of labor that separated these elements. In this poster we suggest that collaborative structures influenced students' participation, or lack thereof, during a computational craft design project, presenting a representative case where student design teams segregated tasks amongst themselves and worked in isolation. We look at the relationship between students' division of labor to reflect on the hybridity (or lack thereof) of the computational craft media and consider implications for learning.

Context & Methods

In this study alternative high school students designed tangible/digital pets over the course of 12 workshops. Students at the alternative high school have failed so many classes at the traditional high school they need intensive remediation to graduate. This project targeted those students in hopes of drawing them into interesting areas of design and computation. During the study we collected surveys, field notes, video recordings, and student interviews, focusing on collaboration in three design groups. We drew on activity theory (e.g. Cole, 1996) to analyze the relationship between students' division of labor in their collaborative groups and the nature of the design project (the tool). We began by identifying and comparing episodes of collaborative interaction (an exchange of three or more turns) and potential collaborative interaction (i.e. one student asking a question of another related to the project). We focused on what students attended to during each episode then corroborated these episodes with specific utterances in student interviews. Here we present the case of one group, Tegan, Rocky & Ted, a junior girl and two senior boys, who worked as a team using Scratch (a media-rich programming environment) and PicoBoards (an external logic board) to develop a whimsical interactive physical creature. Their pet, a monkey, resembled recently popular children's toys like Zhu Zhu Pets and Webkinz with both physical (a fluffy real-world body) and virtual (an interactive avatar) elements. Tegan, Rocky & Ted programmed the monkey's interactions on the screen via inputs from sensors, buttons, and sliders embedded on the PicoBoard within the pet's body.

Findings

Our analyses draw on three groups of students, all of whom divided roles amongst themselves and in turn reified existing interests and expertise. For the sake of space, in this poster we focus on Tegan, Rocky & Ted's collaborative group, but the findings reflect the relationship between division of labor and lack of integration in the computational craft across all groups. The full poster will illustrate activities of the other groups as well.

One of the first steps that Tegan, Rocky & Ted took was dividing the design task into separate parts: programming the virtual pet, crafting the physical pet, and planning the interface between them. After this decision they rarely exchanged ideas during the design task. For instance, on two important days of the workshop (days 7 and 10), the group interacted together regarding their design for only 14 of 80 minutes of workshop time. Tegan claimed ownership of the physical pet design, leaving her partners to do the computer programming. As Rocky said, "Tegan pretty much made the pet and me and Ted pretty much programmed." Not only this, but Tegan became so attached to her physical pet design that she refused to let her partners collaborate with her on the design. At one point, when Ted tried to assist Tegan with a specific bit of construction, she forcefully took the pet away from him saying his contribution was, "Not perfect". Rocky admitted, "She would get mad at us if we tried touching her pet". The nature of the work was individual and illustrates how divided the tasks were: the monkey was "her pet" not "our pet."

By disassociating herself from other elements of the project, Tegan prevented her group's project from being as successful as it could have been. In an interview, Tegan admitted she let her partners "do whatever they wanted" with the computer program. In fact, once the craft materials arrived, Tegan did no further programming and rarely looked at the computer. Thus the effect of compartmentalization; Tegan was at once fanatical about her physical design and cavalier about the virtual counterpart. This disparity had ramifications for the students' final product. For example, on the last day of the project, before students demonstrated their pets to invited guests in a design exhibit, Ted expressed concern that their monkey looked different on screen versus real life. For instance, the physical pet wore a scarf and mittens while the virtual pet had prominent freckles and no accessories. Ted argued that this was a fundamental problem with their design project in that people would not be able to tell the two elements went together. Tegan rebuffed his argument, saying the pets looked the same and continued making changes to the physical monkey, widening the gap between tangible and virtual design. Not only did Tegan refuse to address her partner's concern, she was disinclined to engage in other parts of the project even in situations where the amalgamation of the overall design might reflect poorly on her efforts.

Perceived expertise influenced students' participation within their groups. For instance, when asked why the group broke up responsibilities, Tegan replied, "Well, cause they're (Rocky and Ted) not really crafty and also they'd just mess it up because I had an idea in my head." The perception that the boys were not crafty, shared by the boys, resulted in the boys' lack of opportunity to design with the crafts. The assumption that computational crafts provide a pathway to computation and also deliver students to engage in new disciplines does not always hold. In this case, the opposite was true, Tegan abandoned programming in pursuit of her interest in physical pet design; Rocky and Ted were not encouraged to craft and were rebuked when either one attempted to contribute. Similarly, Tegan and others in the role of crafter rarely accessed the computer and did little to no programming. As observed elsewhere, division of labor has the potential to aggravate rather than ameliorate changes in expertise in often-stratified classrooms (Abraham & Wilensky, 2005).

In light of students' divided collaboration, we suggest the need for a framework considering the actual hybridity of these media. As hoped, the tangible/digital pet design project provided multiple entry points for students with different interests, some in crafting and others in programming. However, rather than being interdependent, the craft and computational media were dichotomized by students, allowing prior interests and expertise to dictate participation. Students divided tasks and attended to different parts of the design, which has potential implications for the development of new interests and learning. This need not be the case, but it provides a word of caution to educators and researchers excited about the potential in the Maker movement. Rather than assuming that tangible/digital crafts are promising simply because they combine approaches, we need to develop models that see hybridity on a continuum and research effects of these media on learning and interest development.

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Collaboration in a Non-Digital, Computational Game Space

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Abstract: An investigation of collaboration was conducted in a non-digital, computationally-minded board game, *Pandemic*. A heightened collaborative context was developed for the game, as a means of investigating collaboration and play. Content codes to capture collaboration (help-seeking) and computational thinking were applied to verbal utterances (n=80 turns), with Discourse analyses applied to uncover interpersonal dynamics in the space.

Introduction

In this paper, computationally-supported collaborative learning is investigated within a tactile play space. The forms of collaboration and computational thinking that arise through the play of a single commercial, cooperative, strategic board game, *Pandemic* (Leacock, 2007), are discussed. The game was designed as a computational system for players to cooperatively play against; with a deep look at the play of this game, the conception of "computation" is broadened to incorporate algorithmic, rule-based practices, while also pragmatic benefits of such systems for researcher manipulation and experimentation are advocated.

Previous work has developed understandings of the forms of computational thinking (see Berland & Lee, 2011; Berland & Duncan, 2012), and help-seeking (Duncan, Boecking, & Berland, 2012) within the game. A common thread has been a focus on the naturalistic play within the game's rule constraints, and how changes to the computational game structure of the game can elicit different collaborative and computational practices. The emphasis in this paper is upon unpacking *collaboration* within a specific context for learning — how can we understand the ways that such manipulations to the collaborative, computational structure of a game give rise to different forms of interaction? And what might this indicate about how games work as computational and interactional rule-based systems?

Method

Pandemic is a commercial, collaborative game in which participants work together to rid the world of four diseases simultaneously ravaging the globe. Adopting individual roles (e.g., the Scientist or the Medic) with unique abilities/responsibilities, players are encouraged to work together in whatever way they see as most effective. Participants in this study were provided all game components, along with an additional rule dictating that one of the unused roles in the game would be controlled by all players as if it were another person, referred to as the “ghost player” condition.

Data from two (n=2; n=3) runs of the game were analyzed in the present study. Both sets of players were undergraduates at a Midwestern University in the United States, and all participants were unfamiliar with the game before participating in the study. Participants were video recorded during play, with the verbal interactions of each group first transcribed for further analysis. All verbal interactions between players were transcribed. In order to capture vocalized consequences of the heightened collaborative context (the "ghost player" condition in these play sessions), a set of codes to capture "help seeking" (Nelson-LeGall, 1981; Aleven, et al, 2006) utterances was also developed, including capturing when help on Rules were *Requested, Given, Received and Argued,* as well as when help on Strategy was *Requested, Given, Received, and Argued*. Please see Berland & Duncan (2012) for computational thinking codes.

Results

Computational thinking codes were quite highly applied, with Simulation and Algorithm Building the highest-coded of the two “ghost player” groups (the only codes crossing 40% applied). Strategy-based help-seeking codes were applied somewhat more than rules-based, perhaps indicating a trend toward strategic discussions in this heightened collaborative context. Since *when* each player was speaking was key (the “ghost player”), the context of the game at each point was captured in three forms for each player/turn combination and which player’s actual in-game turn was occurring: “On Turn” contexts, “Non-Turn” contexts, and a “Ghost” context. The percentage coded for each varied widely across the set of computational thinking and help-seeking codes. Most relevant for this study was the variation within the “Ghost” player/turn contexts.

Several patterns emerged in this comparison. First, there were zero codes applied for the rules-based help-seeking codes within the Ghost contexts; on “ghost player” turns, no participants in either group had utterances that indicated a discussion of the game’s rules. Additionally, strategy help-seeking codes were similar for most codes other than Strategy Argued, which appeared to be quite a bit higher (20% of the Ghost context player/turns vs. 8.3% of the Non-Ghost contexts). And, for the computational thinking codes, two major trends seemed apparent from these data: (1) There appeared to be a greater proportion coded for each of the computational thinking codes for most of the codes, and (2) Algorithm Building coded greater in Ghost contexts than that for the Non-Ghost contexts (60% for Ghost contexts vs. 55% for Non-Ghost contexts).

Finally, following Duncan & Berland's (2012) and Duncan's (2010) connected content coding/Discourse analysis approach, content coding was used to select data for qualitative Discourse (Gee, 2010) analyses. For each of the help-seeking codes, the greatest proportional disparity between Non-Ghost contexts and the Ghost context was Strategy Argued, while for the computational thinking codes, the code with the greatest degree of saturation (and most applied code overall) was for Algorithm Building. Thus, these two highly-applied codes were singled out for co-occurrences: In the first (2-player) participant group, Algorithm Building and Strategy Argued co-occurred four times: in turns 2, 6, 11, 14. In the second (3-player) group, the codes co-occurred once (in turn 10). Of these, two player/turn combinations (group 1, turn 6 and group 2, turn 10) were also during the "ghost player" turn, and thus coded as Ghost contexts. Group 2, turn 10 was selected to further investigate; in this turn, players (Aqua, Bryson, and Claire) discussed strategies for the "ghost player" and ridding the board of different disease tokens (yellow and black, in this case), as well as the placement of the "Ghosty's" token on the map and strategies for future players (Claire, in this case).

Discussion

First, the heightened collaborative context of the "ghost player" condition seemed to give rise to a number of computational thinking practices, as evinced through the computational thinking codes (matching results found by Berland & Lee, 2011). With the addition of the help-seeking codes to the analysis, however, it seemed collaboration was potentially complicit in the computational thinking practices found within the space. The lack of rules-based help-seeking during the Ghost context was a surprise; the heightened collaborative context of the "ghost player" may have given rise to a greater degree of strategic discussion since the lack of player investment in a particular role in the game (as it was the fictional player's turn) may lead to players' feeling less of a need for rules clarification.

Additionally, the Discourse analysis highlighted a gap between the Strategy Argued/Algorithm Building activity and the *consequential* actions of the group. Though a heightened collaborative context seemed to encourage more discussion of strategy and potential computational, there was still a general deficit of computational thinking in this context. This disconnect may be reflected in the role of Claire in this case — while the game (and our manipulation) was structured to foster collaboration between the participants, *individual* goals and play style clearly played a role. Claire was the only player in this case to discuss her own goals, and to suggest an imperative for future action; it is notable that the Strategy Argued/Algorithm Building in this case was ultimately unrelated, indicating that individual roles may have driven some choices.

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The Long & Winding Road to Collaborative Observational Practice

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Abstract: A central challenge of observational practice is to reach agreements about what an individual sees with what others see. We used a case study to trace how computer tools—in concert with small group and whole class discussions—mediate collaborative observational agreements in a middle school classroom. Results suggested that shifting conceptions of nutrients affected student observations. Our analysis examines how this was temporally, materially, and socially mediated leading to convergence in observations and understanding.

Observation is fundamental to scientific practice and to how scientists generate new knowledge. A central challenge of observational practice is to reach agreements about what an individual sees with what others see (Daston, 2008). To address this challenge, scientists have forged cultural tools—language, equipment, and disciplinary systems of knowledge and practice—that enable the collaborative construction of shared vision (Goodwin, 1994). Although observation plays a central role in science, we know little about how novice observers develop into scientific observers (Eberbach & Crowley, 2009) and how computer tools might support such development. In this paper, we explore how computer tools mediate middle school students' agreements, observations, and knowledge of nutrients in a pond ecosystem. We do this by examining the collaborative observational practices that facilitate agreements about observed phenomena.

Methods

This study is part of a program of design research that develops and explores computer-based instructional interventions that mediate middle school student understanding of natural systems (Hmelo-Silver, et al., 2011). The context for this analysis was a 6-week unit on aquatic ecosystems. The unit was organized around the problem of fish dying suddenly in a local pond. Working in small groups, students engaged in inquiry by using assorted scientific evidence, including computer simulations, a computer modeling tool, authentic data, and student worksheets. Video data and student-generated artifacts served as our primary data sources. Although we generally focused on one group of four students, we made forays into whole class interactions to trace the path that students took to achieve shared understanding of *nutrients* in a way that enabled collaborative observation of scientifically meaningful patterns.

Results and Discussion

In the results we show how complex interactions among small groups, whole class discussions, and interactions with various tools led to collaborative construction of shared meaning of *nutrients* in a pond ecosystem (See Figure 1).

Questions about the meaning of *nutrients* first surfaced during our group's interactions with a simulation that enabled students to explore relations between populations (algae, fish), environmental factors (sunlight, nutrient runoff), and levels of CO_2 and O_2 in a pond ecosystem. Like many novices, this group conflated the term *nutrients* with food, which affected what they expected to observe in the simulation. Conceptualizing *nutrients* to be essentially good for fish, they maximized the amount of nutrients into the pond but were surprised by what they observed: "It's weird that they live longer with less nutrients but they live shorter with less nutrients. So nutrients are bad?" In attempt to make sense of these results, the students repeatedly manipulated the simulation, observed similar results, and grudgingly recorded their findings in their worksheets. Near the end of this session, the teacher initiated a whole class discussion "to make sure they have the same understanding of the simulation." This discussion revealed little agreement about what constituted *nutrients*: Students typically described *nutrients* as food, animal waste, or fertilizer, whereas the teacher characterized *nutrients* as chemicals that support life processes.

The following day, the group continued to explore the simulation and to revise their computer model to explain why the fish died in the pond. They agreed to include several system relations, including those that connected photosynthesis with algae, oxygen, and water temperature. The group also agreed to include *nutrients*, but did so in a way that isolated *nutrients* from the rest of the model, suggesting that *nutrients* was something of a black box. The question for the students remained, "If it isn't food, then what is it?"

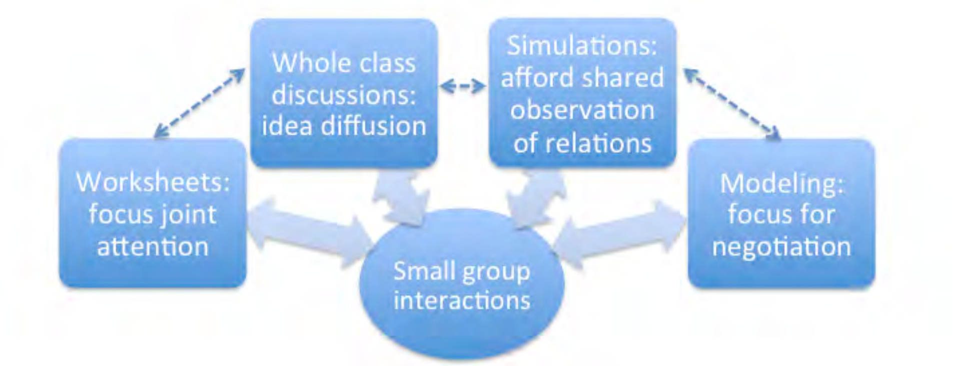

Figure 1. This model shows the many pathways to constructing collaborative agreements about the meaning of nutrients in a pond ecosystem. Convergent conceptual change is mediated by observational practice, which is distributed across time, social interactions, and material resources.

In practice, the teacher's observations were substantially different from those of the students: She observed functional relations at a micro-level (i.e., chemical) whereas they saw structures in isolation. But as students continued to manipulate other simulations featuring micro-level processes (e.g., decomposition, nitrification), complete worksheets that narrowed their observations of the simulations, negotiate modeling decisions, and participate in discussions they slowly began to reach certain agreements about what constitutes *nutrients* ("Decomposers make *nutrients* from dead matter"). Agreeing among themselves that *nutrients* are micro level structures that involve micro-level processes also brought them in closer alignment with how the teacher conceptualized *nutrients*. In time, the group eventually decided to move *nutrients* into the model proper, connecting them to decomposers and fish with a vague claim that "the *nutrients* are affecting the fish in some way."

In conclusion, the path to reaching agreements that enable seeing what others see was neither straight nor simple. Technology offers opportunities for conceptual convergence as learners have opportunities to display, negotiate, and repair their ideas (Roschelle, 1992). Thus, engaging with simulations and modeling tools as well as whole class and small group discussions mediated agreements. The simulations and small group discussions were occasions for individual groups to engage in collaborative observational practices and for negotiating what they had noticed through disciplinary content. The whole class discussions provided a context where the teacher could help learners develop and apply appropriate disciplinary lenses. The model was the place for students to make their thinking visible and to articulate their expectations about the meaning and role of nutrients in the pond ecosystem. These agreements transcended simply naming objects to describe behavior or form, but enabled learners to agree on shared observation of patterns of form, function, and process. The implications of our analysis suggest that the long and winding road of convergent conceptual change is mediated by observational practice and that this practice is distributed across time, tools, and social interactions.

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Do You Speak Math? Visualizing Patterns of Student Technical Language in a Mathematics MOOC

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Abstract: The recent advent of massive open online courses (MOOCs) has created an incredibly vast, rich, and largely unexplored body of data. We have analyzed one MOOC by visualizing the language used by students in their online forums, connecting vocabulary to traditional performance assessments throughout the course, prototyping a tool for future use across courses and platforms.

Background

Learning is a dynamic process of interactions between learners, resources, environments, and instructors (NRC, 2000). In a massive open online course (MOOC), these interactions take place within a distributed learning environment, bounded by the decisions made by faculty around the design of instruction, content, and assessment, as well as platform technological features and the incredible range of student backgrounds and intentions (Grover, Franz, Schneider, Pea, 2013). A key challenge of this new space is assessing learning – researchers have yet to establish definitive metrics about which data will provide the most insight into how people learn in MOOCs, and data useful for researchers may not be the same as informative data for instructors or for individual students. In addition to commonly used assessments of performance, such as exams and attitudinal surveys, learning in a technical field, such as mathematics, can be viewed as the acquisition and use of professional or "academic" language (Pea, 1990; Van Oers, 2000). Successful mathematics education of any kind – online, face-to-face or blended – should result in capabilities to participate in mathematical discourse. Most importantly, students must be able to engage in mathematical communication and argumentation with their peer community. "The meaning of representations such as words and diagrams in a community becomes evident through their use and the reshapings of their meanings through commentary by other participants of learning conversations" (Pea, 1990). The course forums provide a clear record of interactions within exactly such a peer community.

Visualization can serve as a powerful approach for exploring and making sense of the complex and multidimensional set of performance data (Bienkowski, 2012), including the connections between multiple dimensions of performance. With this in mind, we have developed a prototype for the visual exploration of multidimensional features of student learning in MOOCs.

Forum and Survey Data: Research in Progress

The specific question that the visualization is designed to help answer is: how does the adoption of technical, academic language in the *Introduction to Mathematical Thinking* MOOC on Coursera correspond to instructor language use and student performance on course assessments? More specifically, when do students begin to use formal academic language introduced by the instructor, and does that timing correspond to their performance on other, more traditional, performance metrics?

The *Introduction to Mathematical Thinking* MOOC was a 7-week course taught in Fall 2012. As part of the course, students had access to a discussion board where they could socialize, seek help, and explore mathematical concepts. The course began with 44,432 active students. Of these, 5,066 posted in the forum at least once for a total of 3,235 threads consisting of 33,828 individual posts. Of the forum participants, 1,214 completed the course pre- and post-survey, and this group forms our population of study in this visualization.

The visualization has three parts. First, individual student scores on problem sets are encoded in a parallel coordinates graph, with score as a percentage indicated by vertical position. This graph also contains pre- and post- class survey responses to the question, "In general, how relevant to you are the things that are taught in mathematics classes?" Lines for students who never used the currently selected word are red, so they can be distinguished from lines for students who did use the word, in blue. Data for specific students or groups of students can be selected, and their trajectories through the course assessments will be highlighted. Below that, a timeline shows the median time of first forum use of the word for the students selected in the top graph, as compared to the time of the instructor's introduction of the word. Finally, a histogram shows all use of the word over the entire course. Live visualizations for several words of interest are available at www.stanford.edu/~bperone/wordUseVisualization.

The primary goal of this visualization tool is to aid in exploratory data analysis (Tukey, 1977) by highlighting trends that can be pursued in more depth using other analytical tools. It can also be adapted to answer similar questions around language adoption and performance in other MOOCs. Finally, it provides a prototype for real-time exploration of the interactions between multiple types of performance data.

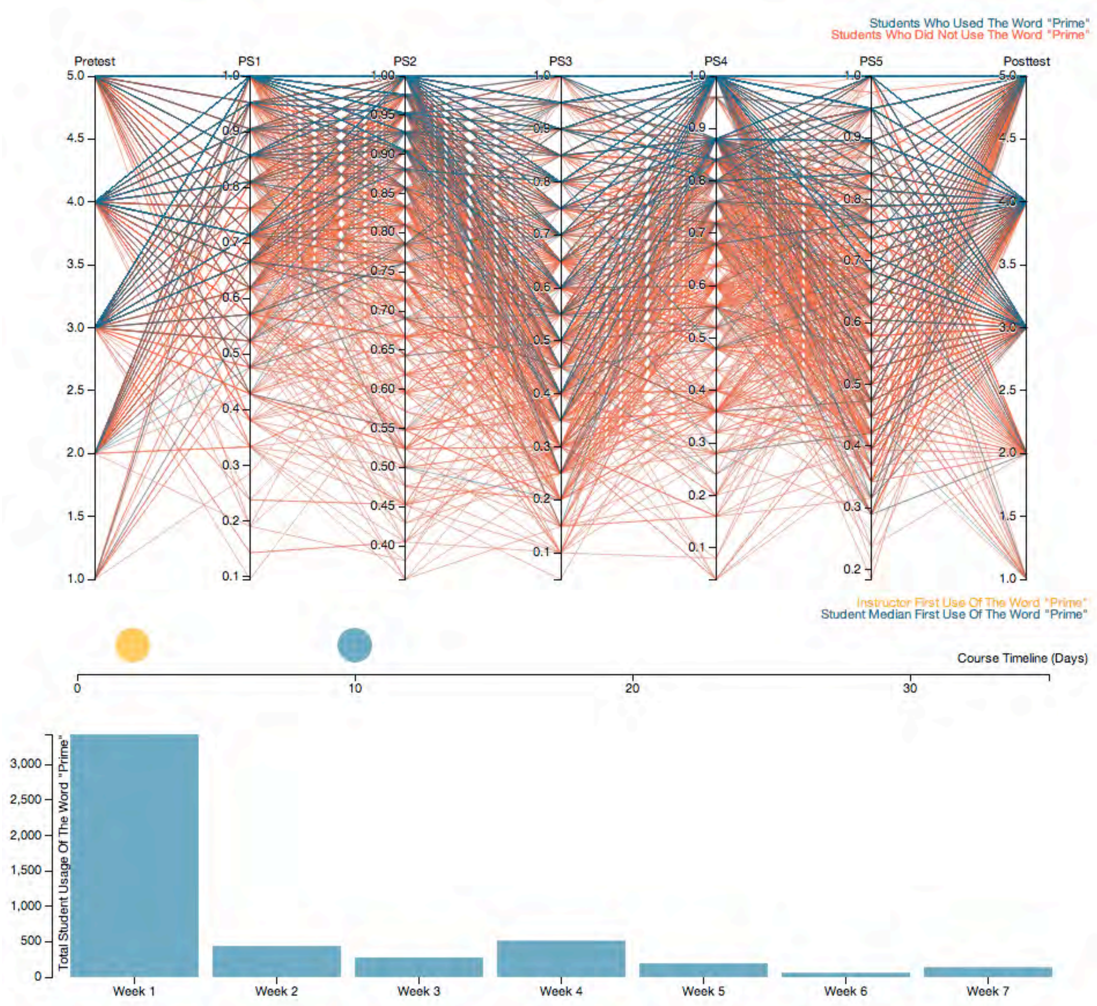

Figure 1. A screenshot of the visualization

Future Work

An obvious limitation of our approach is the lack of context for word use. Future work could use more sophisticated natural language processing to examine not only when words are used, but how. For example, we could use markers for exploratory language (Ferguson, Buckingham Shum, 2013), or determine whether key words are used declaratively or interrogatively. Separating out individual forum threads and looking at the conversational interactions around specific topics could also prove illuminating.

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Formative Assessment Using Repertory Grid Technique via Facebook: A Social Media Tool to Support E-Learning

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Abstract: Designing technologies that enhance formative assessment in e-learning is crucial for improving teaching and learning in these environments. Whereas many studies have examined the effectiveness of formative assessment in traditional classroom contexts, researchers have only recently begun to explore technology-enhanced assessment. To understand how we can take advantage of existing social media tools to support e-learning, we describe a Facebook app called FARGO that offers potential to support teachers and students with assessment for learning.

Introduction

Designing technology tools that can enhance assessment in e-learning environments is crucial for improving teaching and learning in these contexts. Innovative assessment tools may be embedded in the technology-enhanced learning environment. When closely aligned with instructional goals and course activities, they provide teachers and students with supports for cognitive and motivational processes. Whereas many studies have examined the effectiveness of formative assessment and feedback in traditional classroom settings (Andrade & Cizek, 2010; Black & Wiliam, 1998; Noyce & Hickey, 2011), less is known about transferring assessment practices from face-to-face to online environments (Beebe, Vonderwell, & Boboc, 2010). In higher education contexts, there is a paucity of studies on online formative assessment (Gikandi, Morrow & Davis, 2011). Therefore, our objective is to investigate how tools for formative assessment embedded in Facebook and course activity structures can support online and blended teaching and learning. Online formative assessment tools may: 1) provide just-in-time feedback on learning progress to students; 2) help teachers reflect on their teaching practices and enact change to optimize learning; and 3) support students' self-regulated learning (Zimmerman & Schunk, 2001).

Conceptual Framework and Methodology

Guided by a socio-cognitive knowledge building (Scardamalia & Bereiter, 2003) framework, this design-based research study explores opportunities for concurrent, embedded and transformative assessment (Scardamalia, Bransford, Kozma, & Quellmalz, 2009) using a Facebook app called FARGO (Formative Assessment using Repertory Grid Online). The first iteration analyzed data from 26 participants from a blended undergraduate marketing class. The second iteration analyzed data from 13 participants in a blended B.Ed. instructional technology course. The third iteration analyzed data from 5 participants in an online M.Ed. e-learning course.

FARGO: Software and Preliminary Findings

FARGO is software designed by Chris Teplovs to elicit repertory grids for the purpose of formative assessment. It takes advantage of the existing Facebook infrastructure and employs the well-established repertory grid technique (RGT; Fransella, Bell, & Bannister, 2003; Kelly, 1955). RGT has been used successfully not only in psychology but also in education and more recently, in computer-supported collaborative learning research (Aditomo, Calvo, & Reimann, 2009; Vatrapu, Reimann, & Hussain, 2011). FARGO collects data efficiently and overcomes the time-consuming nature of conducting interviews using the RGT.

In this study, FARGO is deployed as an exercise embedded within the broader course learning activities in a learning management system. FARGO prompts participants to think about the relationships between elements of a particular topic. For example, B.Ed. students were asked to think about the relationship between six instructional technologies in two steps: 1) the widely-adopted triadic sorting of elements for personal constructs and 2) subsequent five-point Likert-scale rating of the elements (Fransella, Bell, & Bannister, 2003). Constructs are defined as "a way in which some things are construed as being alike and yet different from others" (Kelly, 1991, p 74). Thus, participants go through a series of prompts that presents three technologies (e.g., Smartboard, smartphone, tablet) at a time. For each triad, they are asked to identify the element that is different (e.g. Smartboard) from the other two elements (smartphone, tablet) and to state how it is different (e.g., presentation technology). Then, the participant is asked to state how the two remaining elements in the triad are similar to each other (e.g., mobile technologies). These differences and similarities are used to label the extreme values of the Likert scale (e.g. 1 and 5). The remaining elements (other technologies) are rated on this construct. The triadic sorting process is repeated a total of eight times, resulting in a total of eight constructs elicited from each participant.

After the construct elicitation, each participant is shown a visual representation (i.e. table) of the relationships they identified between different technologies. Showing students their own repertory grid makes their learning "open" or visible to them and provides formative feedback to encourage students to exercise cognitive responsibility over their learning. The course instructor also completes the exercise. This enables students to see how an expert conceptualizes the same topic.

In the first iteration, 25 of the 80 undergraduate marketing students (31%) completed the FARGO exercise. The instructor's constructs on the relationships revealed dichotomous, unique constructs with virtually no overlap with each other, and a spread of values (1 to 5) in rating the elements. This suggests that the instructor, an expert, constructed complex understanding of the relationship between the elements. Student grids showed a range in quality, with more advanced student grids showing overlap with the expert's grid in features, and other student grids featuring repeated constructs or constructs with one similar pole. Another characteristic of less advanced student grids is that the elements were rated only by polar values (i.e., only 1 and 5, not 2, 3, or 4). These qualitative and quantitative features of repertory grids were explored in the following iterations.

In the second iteration, 13 of the 46 (28%) B.Ed. students who gave informed consent completed the FARGO exercise. In the third iteration, all five M.Ed. students who gave informed consent completed the FARGO exercise. To analyze quantitative data from second and third iterations, we counted 1) the number of non-polar values (i.e., 2, 3, 4) for each of six elements rated on eight constructs and 2) the number of unique constructs, or "themes." For example, a student might identify three unique constructs ("software-hardware", "entertainment-educational", and "big-small") and repeatedly use the same construct when rating different triads. The non-polar values were summed for a total non-polar value. The mean number of non-polar values for B.Ed. students was 13.3 and the mean number of themes was 5.9. The mean number of non-polar values for M.Ed. students was 14.5 and the number of themes was 6.7. No significant differences were found between B.Ed. and M.Ed. participants using independent samples t-tests for non-polar values ($t(17)=.30$, $p=0.77$) and mean number of themes ($t(17)=.92$, $p=.37$). Confirming our findings from the first iteration, repertory grids elicited from experts tended to have comparatively fewer polar values and little overlap between constructs.

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Supporting Feedback Uptake in Online Peer Assessment

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Abstract:
Starting point for the present study were students' problems in academic writing. The goal of the study is to improve students' writing in a peer assessment setting. Sixty-seven students participated in an online writing task. We investigate whether providing sense-making support during feedback reception leads to increased feedback uptake, better revisions of the original text, and improved writing skills, as compared to a condition without sense-making support.

Introduction

Writing and revising scientific texts is a challenging task for university students. The main challenges for inexperienced writers are to detect errors in the text and to find appropriate ways to revise the text (Hayes, 2004). Receiving feedback early on in the writing process is important, but often students fail to capitalize on the feedback they receive as they do not take it up (Van der Pol, Van den Berg, Admiraal, & Simons, 2008). Problems with understanding the feedback and lack of reflecting on the feedback can be cited as reasons for the lack of feedback uptake. Support is needed to help students in making sense of feedback with the goal to prevent rejection of the feedback, to increase elaboration and understanding of the feedback, and thus to improve feedback uptake.

Peer assessment scenarios can help to meet the challenges of academic writing, because peer feedback can be provided more timely and more frequently than feedback of the course instructor (Falchikov & Goldfinch, 2000). Typically, peer assessment starts with a task asking the assessee to create a product (i.e. an academic text). Secondly, the product is reviewed by one or several assessors resulting in feedback provision. Thirdly, assessees receive feedback. And lastly, assessees revise their own product based on the feedback of the assessors. Unfortunately, peer assessment activities do not necessarily lead to learning (Kollar & Fischer, 2010). Major problems during peer assessment are related to the assessee's failure of feedback uptake (Van der Pol et al., 2008). Feedback uptake refers to changes made to the assessee's product during revision that are clearly based on and related to received feedback. Feedback in academic writing typically includes comments about problems in the text and suggestions for revision. But even if students receive comments that point toward errors in the text, they have problems to capitalize on the feedback. Writers often reject feedback upfront without engaging in sense-making processes or have problems with managing the feedback (Boero & Novarese, 2012). Sense-making processes are crucial, however, because understanding the problems is decisive for improving performance in peer assessment (Schunn & Nelson, 2009).

We expect that providing assessees with sense-making support during feedback reception will improve feedback uptake. The hypothesis with regard to academic writing is that better feedback uptake would lead to better revisions of the original text and yield improved writing skills. This hypothesis is investigated in the present study.

Method

Altogether, 67 students (13 male, 54 female) served as participants. The students were recruited from three courses of the bachelor program in educational sciences at a major German university. Students participated in the study as part of their regular course activities. The study followed an experimental design with sense-making support as independent variable. Students were randomly assigned to one of two conditions: Sense-Making Support condition and No-Sense-Making Support condition. The sense-making support aimed at encouraging the student to reflect on the feedback. Students were asked to rank and to judge received feedback and to plan their corresponding revisions (Figure 1).

Comment	I understand the comment.		I agree with the comment.		I am going to use the comment to revise my text.		I am going to improve my essay by doing the following:
	Yes	No	Yes	No	Yes	No	
Comment 1	□	□	□	□	□	□	
Comment 2	□	□	□	□	□	□	
General Questions							
In my opinion the main points of critique are…							

Figure 1. Sense-Making Support

The writing task was embedded in an online peer assessment activity that was conducted over a period of 10 days. The activity consisted of three phases. During phase (1) Essay Writing, participants created an essay of 600 words, in MS Word. The content of the essay was related to identity formation, a well-known concept in psychology. During phase (2) Feedback Reception, each student received comments on their essay from an assessor (Figure 2). The feedback included 12 comments on five writing criteria for mistakes that frequently occur in students' written products: Sequence/Logic of Argument, Transition Words, Nested Sentences, Direct/Clear Reference and Filler Words. Students were told that the feedback was given to them by a peer, however, in reality the feedback was given by the first author of this paper and by trained tutors in order to control for the amount and kind of feedback. Note that all participants only took the role of the assessee. The experimental variation (Sense-Making Support vs. No Sense-Making Support) was implemented during the Feedback Reception phase. During phase (3) Revision, students revised their essays based on the comments they had received. We used Moodle (Moodle, 2013) to distribute instructions and questionnaires. Also, students submitted their essays and revised essays to this platform. Feedback uptake, improvement of text quality and writing skills (Pre-Post) were assessed as dependent variables.

Connect sentences. The order of the sentences is logical, but a connection is missing. Try to connect the sentences in order to establish coherence.

Figure 2. Sample comment given to the students as peer feedback

Analysis & Results

The data are currently being analyzed. Feedback uptake is assessed by analyzing quantity of revisions, quality of revisions, and self-perception of feedback use. Improvement of text quality is assessed by comparing the quality of the original essays to the quality of the revised essays. Writing skills are assessed using parallel pre- and posttest versions. The pre- and posttests assessed two distinct skills related to academic writing: problem detection and problem correction. The test consisted of a text with 10 erroneous passages. For assessing problem detection skills, students had to highlight and label the problems in the text. For assessing problem correction skills, participants were asked to correct erroneous text passages. Errors were again related to the 5 writing criteria representing common mistakes. By analyzing the relationship of feedback uptake, on the one hand and improvement of text quality and writing skills on the other hand, we will be able to evaluate the benefits of feedback uptake with regard to improving student procedural and declarative writing skills. Results will be presented at the conference.

Significance and Contribution of Research

The present study will contribute to theory building in the area of online peer assessment and to research on the acquisition of writing skills in university settings. On the practical side, our findings will provide university teachers with guidelines for supporting students in the assessee role in online peer assessment scenarios.

Acknowledgments

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Structuring the PA Process: Impact on Feedback Quality

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Abstract: The present study examines the impact of structuring the peer assessment process in a wiki-based CSCL-environment. Three conditions are involved: a non-structured, a basic structured, and an elaborated structured peer feedback condition. The main aim of this study is to foster insight into the aspect of peer feedback quality by focusing on the impact of the level of structuring and on the implemented measures to assess peer feedback by both peers and instructor.

Introduction

By structuring the peer assessment (PA) process in a wiki-based CSCL-environment, this study investigates the impact on the quality of the peer feedback. Previous research highlighted the added value of PA in higher education (Topping, 2003) due to direct engagement in the learning process (see also Topping, 1998). Peer feedback can be seen as a specific approach of peer assessment, which aims to involve students in assessment for learning by asking them to provide fellow students with opinions, ideas and suggestions for improvement (Black & William, 1998). However, previous literature pointed out that students sometimes perceive peer assessment as unfair and often question peers' qualifications to review and assess their work (Kaufmann & Schunn, 2010; Strijbos, Narciss, & Dünnebier, 2010). Previous research emphasizes on the importance of students' feedback ability (Van Zundert et al., 2010) and the preference of using multiple peer markers to enhance accuracy of peer assessment (Bouzidi & Jaillet, 2009). Previous research also highlights the learning benefits of offering structure in a CSCL-environment (Strijbos & Weinberger, 2010), especially when certain support or structure is provided that further specifies the roles and activities for the involved learners (Fischer, Kollar, Mandl, & Haake, 2007; Schellens & Valcke, 2006; Strijbos, De Laat, Martens, & Jochems, 2005). Recently, research emphasizes on the need for structure and support to ensure effective feedback (Poverjuc, Brook, & Wray, 2012). Therefore, the present research focuses on the impact on the feedback quality when structuring the peer assessment process in a wiki-based CSCL environment. Empirical evidence suggests the use of wikis as an ideal CSCL-tool for supporting PA activities and online collaboration (De Wever, et al., 2011). Recommended by previous research, this study incorporates "feedback instruments such as performance scoring rubrics with criteria, or structured feedback forms that force feedback providers to ask reflective questions and give suggestions for improvement could be valuable instruments for increasing the quality of the peer feedback" (Prins, Sluijsmans, & Kirschner, 2006, p. 300).

Methodology

The main aim of this study was to investigate the quality of students' feedback. During one semester, first year university students (N=178) participated in a quasi-experimental study in an authentic context in Higher Education. All students, enrolled in an educational sciences program, were divided into groups (N=37) of maximum five students and were asked to collaborate on writing assignments, in which each group member had to contribute to the wiki by writing three abstracts based on provided articles. Although this study uses only one fixed group member to provide peer feedback on the draft version of another group member, this process was structured (see further). Based on the feedback, the final version of the abstract was constructed together with an evaluation of the received peer feedback. After submitting their individual wiki page with three abstracts, all participating students had to summatively assess the three abstracts of the other group members with the help of a scoring rubric. In the beginning and at the end of the assignment phase, students had to complete a questionnaire including 5-point Likert items evaluating how they perceived the peer feedback process.

During the peer assessment process, students were required to employ a feedback form provided by the instructor, in which the structuring level depended on the condition. Three conditions were implemented: a non-structured peer feedback (NS-PFB) condition, a basic structured peer feedback (BS-PFB) condition and an elaborated structured peer feedback (ES-PFB) condition. Therefore, a more elaborated structure contains more guiding questions to assist students' thinking process during the peer assessment process, than a basic structured form. This study will investigate the impact of the three conditions on the quality of the feedback. Moreover, this study will explore how to effectively measure feedback quality. Therefore, the following hypothesis is examined: A higher level of structuring the PA process will lead to (H1) a higher feedback quality, and (H2) a higher reliability of PA

Analysis
Firstly, the quality of the feedback will be analyzed by the researcher through content analysis, which can be described as "a summarizing, quantitative analysis of messages that relies on the scientific method and is not limited as to the types of variables that may be measured or the context in which the messages are created or presented" (Neuendorf, 2002, p. 10). Secondly, students have to evaluate their received peer feedback through a provided scoring rubric, which is based on the Feedback Quality Index (Prins, Sluijsmans, & Kirschner, 2006). Consequently, this study will examine the reliability of the feedback quality scores between instructor scores and students' scores.

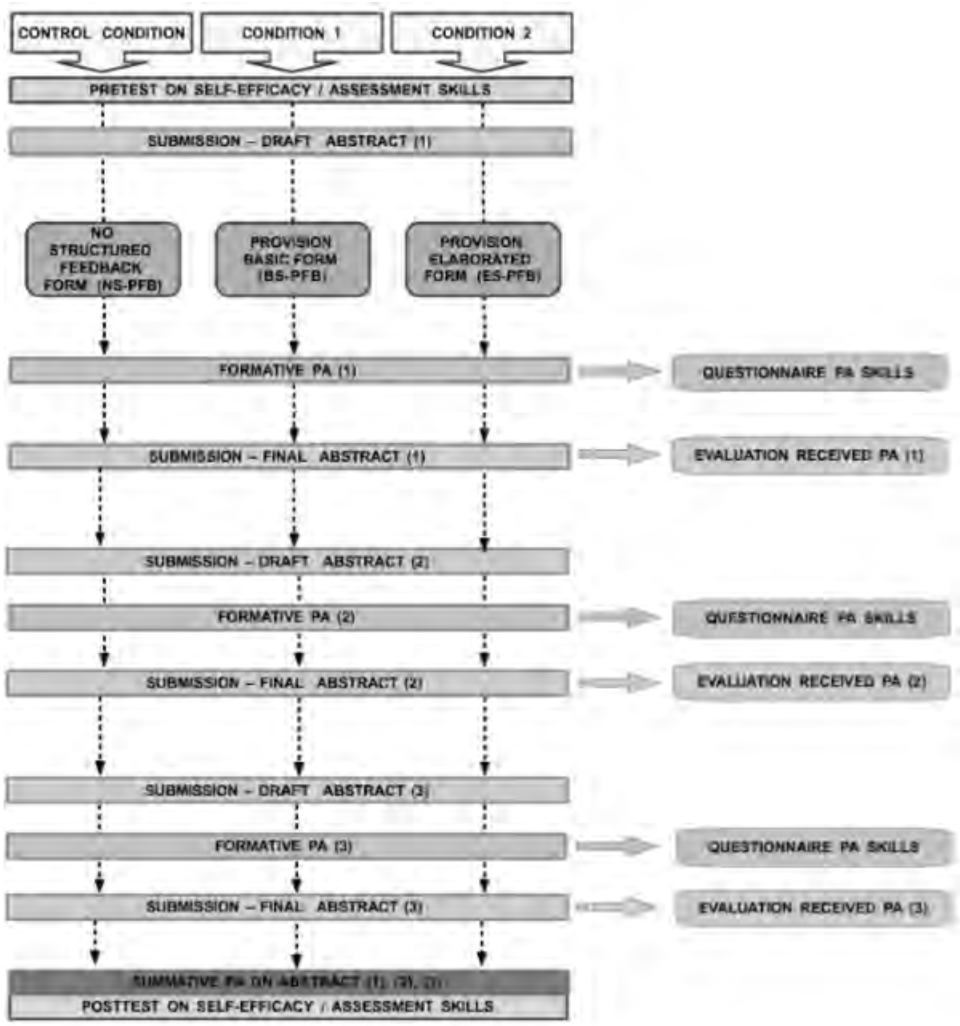

Figure 1. Research design.

Results
The findings of this study will be reported at the CSCL 2013 conference. This research will provide information to what extent the instructor should structure the PA process in a CSCL environment to ensure effective peer feedback, by applying suggested feedback instruments for increasing the quality of the peer feedback. This poster session aims at gathering constructive input on the aspect of feedback quality, and more specifically, on the instructors' intervention to ensure or maximize the quality of the peer assessment process.

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COMPS Computer-Mediated Problem Solving Dialogues

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Abstract: COMPS is a web-delivered platform for collaborative problem-solving conversations. When deployed in classroom exercises the teacher joins the dialogues as needed. The two goals for COMPS are a) environment and protocol that promotes group cognition, and b) machine-generated real time status display showing the teacher which groups need assistance. This poster shows an example dialogue containing group cognition at work and reports the first results of computer classification of student utterances.

Introduction

The COMPS project has students solve problems through monitored, computer-mediated group discussion. We are working in two problem domains: quantitative literacy word problems and computer programming skills and concepts. COMPS dialogues are typed computer chat on web pages. COMPS also contains specialized problem-specific software for exploratory learning. Problem-solving discussions are monitored by the instructor, who can intervene in the discussion (Desjarlais, Kim, & Glass, 2012). Research goals for the COMPS project are broadly: facilitating group cognition in problem-solving dialogues and developing computer monitoring technology to assess the progress of the conversations in real time. COMPS is still under development. We have deployed problem solving exercises in two different classes (Java programming and mathematics education) for testing purposes. We have the first experiments with computer language classifiers.

Example of Group Cognition in Programming Problem Dialogue

Our initial deployment dialogues show many examples of what Stahl (2009) calls *group cognition*. Figure 1 is an extract of students solving a problem in class inheritance in the Java programming language. The students have the problem on paper with multiple-choice answers, the prompt specifies they must all agree on an answer. In this protocol the instructor checks whether the agreed-on answer was correct. Turns in Figure 1 are marked with I (initiate) or R (respond) according to exchange structure analysis. In this dialogue group cognition is achieved by the students taking different roles in the problem-solving process. Our analysis is like this:

- Student A is in control of the dialogue. All but one of the Initiate dialogue moves came from A. And A is the person who evinces the least understanding. However we observe that it is A who suggested a problem solving strategy (turn 4), invoked a reasonableness check on a proposed answer (turn 8), and caused the answer to be summarized in a single argument (turn 18). Student A provided the metacognitive regulation in this process.
- Student B provided most of the reasoning and the summary (turns 5, 7, 11, 13, 19).
- Student C, who participated the least, was the *first* to moot the correct answer into the discussion (turn 16) after only one contribution late in the game (turn 14). Clearly C had been mentally engaged in following the problem-solving activity taking place between A and B.

With A directing and checking the problem-solving activity, B doing most of the figuring out, and C providing the last step, it is clear that these students are indeed reasoning as a group.

Example of Computer Classification of Dialogue Turns

The COMPS project has been using both Latent Semantic Analysis (LSA) and Nonnegative Matrix Factorization to build classifiers that recognize problem-specific features in the dialogues. The technique is to compare dialogue turns to bundles of exemplar sentences (Dion, Jank, & Rutt, 2011). For these results we have been using a quantitative literacy problem: determining whether there is a winning strategy in a Nim-like game called Poison. COMPS contains a facility for the students to practice playing Poison while chatting at the same time. In the Poison dialogues here are three key behaviors that the computer will monitor, with our best achievable LSA recognition accuracy for each:

- Dialogue turns where students express the idea that you want to leave your opponent with 1, 4, 7, . . . tiles. This is a key realization in the solution path. All successful groups come to this conclusion. We can recognize it with 63% accuracy.
- Dialogue directly concerned with playing the game (e.g. who goes next, what move to make). We can recognize these turns with 86% accuracy.
- Dialogue where the students are clarifying the rules of the game to each other. Recognized with 96% accuracy.

As of this writing the classifier has been trained on exemplar sentences taken from verbal dialogues. We will re-train it using typed-chat dialogue collected from students using the online COMPS system before deploying real-time monitoring.

Conclusion

COMPS has been used with four problems (two each in quantitative literacy and programming), on seven different occasions, collecting 48 discussion groups. Hand coding and analysis of the transcripts reveals that most dialogues show evidence of either a) collaboration in problem-solving or b) achieving a common level of understanding. Initial training of LSA classifiers for future real time computer monitoring shows that some categories of utterance are highly recognizable.

Figure 1: Solving a Programming Puzzle in Class Inheritance

1	A	do you guys understand this second problem	I	A Most initiate-response pairs in this group are initiated by A.
2	B	this one is confusing.	R	
3	C	yeah this one got me thinking	R	
4	A	lets try and take it like one output at a time...how are we gong to get this to print Foo_3 first? [*ellipsis dots in the original*]	I	A sets the problem-solving agenda
5	B	we need to first make foo_2 extend foo_2	R	B moots first important idea
6	A	why	I	A prompts for explanation
7	B	because foo_2 starts the main method but it isnt the first thing that prints	R	B explains
8	A	wait hold on..that cant be right its not a choice bro	I	A notices the multiple-choice answers do not include the proposed answer.
		so it has to start with foo 3 or 4		
		or object		
11	B	oh that's what i meant . we have to make foo_2 extend to foo_3 my bad	R	B corrects first idea
12	A	so when you do foo 2 extends foo 3 , the program goes down to foo 3 and prints out "From Foo_3"?	I	A articulates B's idea more fully
13	B	yes and then it goes back to foo_2 to print "From foo_2" .	R	B finishes
14	C	so what is the main calling when it says Object foo_2 = new Foo_1? and for the other	I	C shifts focus to next part
15	A	idk it kinda looks like a swap without the "temp" thing/example Dr. <Instructor> showed us	R	A provides not-relevant analogy
16	C	I got answer c	I	C is first to provide correct answer
17	B	i do too.	R	B concurs
18	A	can you explain it to me because i am confused	I	A prompts for explanation
19	B:	ok , i got it now. (*types first part of explanation, 42 words. Subsequent dialogue elicits rest.)*	R	B explains all

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Measuring Performance Across Space & Time in Online Learning: Identifying Structural Patterns to Promote Scalability

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Abstract: The relationship between group performance and structure in completely online, large scale CSCL learning environments is examined inconsistently. In this study, we examine a set of eight completely online graduate student learning groups in a large scale, asynchronous, fully distributed CSCL environment. We connect group awareness to performance with a comprehensive analysis of the performance and performance changes in all eight groups, paying particular attention to the three case study groups. We look at actual performance as scored on a rubric by two raters instead of grades, and we also survey the group's regarding their sense of "Group Efficacy". The group awareness of each of the three groups is shown to have a relationship to these two performance measures.

Introduction

Computer Support for Collaborative Learning (CSCL) research contributes to understanding of small groups in an online context from the perspective of joint knowledge construction (Kimmerle & Cress, 2008), the influence of argumentation scaffolds on group micro-processes (Stegmann, Weinerger, & Fischer, 2007) and the use of technology for reflection (Yukawa, 2006). Alongside CSCL studies in research focused technical environments, a parallel movement toward large scale, open education at the University level is changing the nature of how higher education is delivered (Creelman & Ossiannilsson, 2011). The need for CSCL research to focus on large scale, deployed learning environments is great; and growing. A close examination of small groups, and their role as an intermediate level social construction between large scale communities and individual CSCL participants is warranted.

To address the scalability of CSCL research across space and time with a focus on small groups in completely online university courses new approaches to performance measurement and evolving structure within these groups is necessary. There are several specific gaps in both the measurement of performance and the description and understanding of small groups as a vital, intermediate unit of analysis in scalable CSCL. First, performance is not consistently measured when it is measured at all in studies of online learning. Student grades are frequently used as a method of convenience, but their limited utility as a measure of learning performance is well documented. Further, there is wide variation in the meaning of words like "online" and "computer supported collaborative learning". In some studies *online groups* refers to courses where students meet partially online and partially face to face (Cho, Gay, Davidson, & Ingraffea, 2007; Cress, Barquero, Buder, & Hesse, 2005; Johnson, Suriya, Yoon, Berrett, & Jason, 2002; Michinov & Michinov, 2008; Michinov, Michinov, & Toczek-Capelle, 2004) and in other studies the groups are composed of geographically distributed subgroups where the subgroups meet face to face (Cadima, Ferreira, Monguet, & Ojeda, 2010). Only a few studies look explicitly at the completely online case (Goggins, Mascaro, & Mascaro, 2012; Goggins, Galyen, & Laffey, 2010). Making performance measurements more systematic and being specific about the contexts and interaction patterns examined in CSCL research will enable further, systematic study of scalable CSCL across space and time.

Identity and Structure Across Eight Groups

Group Identity

		Communication Type		
Group	**Posts in**	**Small**	**Inter-**	**Inter-**
Barriers	208	58.17%	40.87%	0.96%
Get-Along	396	83.08%	15.66%	1.26%
Individualist	103	77.67%	21.36%	0.97%
Canada	189	89.42%	3.70%	6.88%
Catskill	315	100.00%	0.00%	0.00%
Adams	175	97.71%	2.29%	0.00%
Orange	246	100.00%	0.00%	0.00%
Police	14	100.00%	0.00%	0.00%

Table 2. Total posts in each group private discussion area and % communication type by group

Table two shows some basic trends in these communication practices. It is clear that three groups (Catskill, Orange & Police) only communicate within the group discussion board using group oriented language like "we" or other references to the group as a whole. It is also clear that three groups (Individualist, Barriers & Get-Along) participate in a combined interpersonal/group oriented communication pattern. Seven of the eight groups we study are composed of three members, and the eighth group (Canada Group) has four members. Canada Group is the only group with a significant amount of interindividual communication (as explained in the literature review, interindividual communication is between individuals, but in a group context such as a side conversation at a party). This may be an artifact of how communication within a completely online group changes when the size of the group changes from three members to four, and warrants examination in future studies.

Performance

The performance and performance trajectory of each case study group is connected to the identity and structure of the group that emerges from our analysis. Individualist Group and Barriers Group experience declines in performance related to critical events that occurred during the midpoint of the course, module four. Get-Along Group struggles with performance on the task in module four because it is an unstructured design task for which the group's well-established socio-technical practices are ill suited. The most cohesive group adapts slowly, and the least cohesive groups experience difficulty. The relationship between identity, structure and performance in completely online courses appears in these case studies to be a nuanced one.

	Individualist	Canada	Adams	Police	Orange	Barriers	Catskill	Get-Along	Basis for Color Code
Scenario	24	12	**30**	12	24	**33**	18	15	score group
Script	4	**28**	24	**20**	24	28	**22**	**20**	trajectory
Assessment	*3*	*6*	*0*	*3*	*6*	*3*	*18*	*3*	
Total	31	46	54	35	54	**64**	**58**	38	score group

Table 3. Module four rubric scores

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SANCTUARY: Asymmetric Interfaces for Collaborative Science Learning In Shared Space(s)

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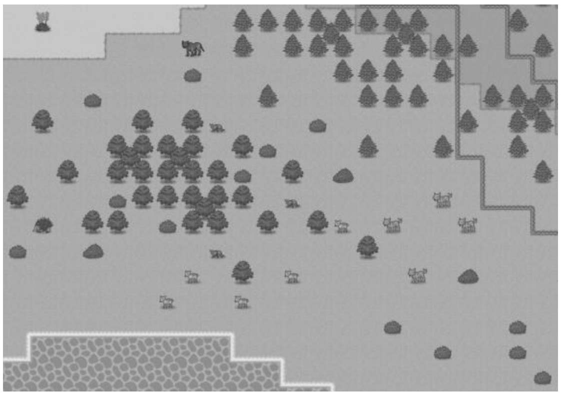
Abstract: SANCTUARY is an interactive and participatory game that allows novices to experience approachable and collaborative exercises in 10th grade biology and math through the lens of ecological problem solving. The chief innovation is the development of asymmetric interfaces on a shared game space, providing different tools and different epistemological frames for each player on shared problems. Students can both become familiar with a way of knowing and be aware of different ways of knowing.

Major Issues/Potential Significance

SANCTUARY is a multiplayer game designed to encourage science learning for 10th grade math and biology students, attempting to promote greater public understanding of science and interest in Science, Technology, Engineering, and Mathematics (STEM) learning. The design descends in part from Elliot Aronson's work on the Jigsaw Classroom (2011), principally in that it requires a group task to be completed by students with a group goal but with individual accountability (through specialized roles). The game is played by two co-located players on two tablet computers (iPads in this version). While both players are seeing the same simulated world, each player has a different set of tools with which to act in that world. The purpose is to elicit quality communication, arguments, coordination, and co-strategization (planning ahead for future turns) between participants. This is an advance over single-player or multiplayer learning game experiences, in which players are rarely required to verbally express and formalize their strategies during play. The project is also intended to provide a counter to a "one-size-fits-all" status quo in learning games.



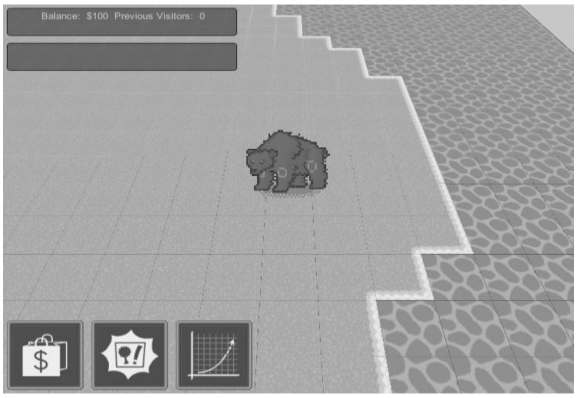


Figure 1. A remote shot of a playing field in SANCTUARY.
Figure 2. A look at a bear through the Mathematician's interface.

The ERIA Interactive group at the University of Wisconsin-Madison's Institute for Discovery has begun work on a very thorough simulation for environmental planning, *Trails Forward* (see Shapiro et al., 2011). The work of these groups though, is principally to help professionals and pre-professionals make careful decisions at the highest level. SANCTUARY aims to reduce the complexity to a manageable level for high school students, as well as to provide them with strictly collaborative goals. Several fantastic games for science learning for this high/middle school audience have emerged in recent years as well, such as Filament Games' *Resilient Planet* (2008) or ERIA Interactive's *Citizen Science* (2011). Single player games do not frequently allow for multiple perspectives on a play space due to insufficient budgeting or scope. Augmented Reality games and participatory simulations such as those developed by Klopfer et al. (2008) have experimented with role-based decision-making, but generally in large workshops that are hours long and require specialized technology. Finally, while this game aims to be located in the tradition of games with asymmetric interfaces, from lightly asymmetric (as in *World of Warcraft* (2004) or *Team Fortress 2* (2007)) to highly asymmetric (as in the *Artemis Bridge Simulator* (2012) or Carnegie Mellon's *Fusion* (2010)), none of these games are designed for science and mathematics learning, and it might be a considerable stretch to teach with them.

Theoretical and Methodological Approaches

The player roles, by virtue of having a constrained set of tools, necessarily represent an epistemology and thus provide an epistemological frame (Shaffer, 2006) on the shared problem space of the game. Shaffer et al.'s (2011) Epistemic Frame Theory posits a frame that consists of the skills, identity, knowledge, values and epistemology of professional practitioners. The theory states that if students can internalize this frame, they will become practitioners in important ways. Shaffer (2006) likens epistemic frames to, "the proverbial 'hats' or 'glasses' we don as we take on a variety of identities or perspectives in dealing with different situations," saying that they, "may represent a … tight linkage between practices and ways of knowing, but at the level of the local cultures developed by individual communities of practice." The biologist player has tools that allow him/her to perform quadrant sampling and tag and recapture studies, for instance, while the mathematician player has the ability to swap out creatures algebraically and to extrapolate future trends using statistical tools. The players must then engage in a third epistemic frame, that of the collaborative practitioners, in order to successfully complete the level together. For instance a level in the game has the goal of sustaining three wildflower species in the ecosystem despite an onslaught of predators. Players then come to understand what it is to know things as a biologist or a mathematician might, but also learn to be collaborative. This allows SANCTUARY to impact a neglected aspect of science and math education, teaching students collaborative skills, particularly problem solving *across* disciplines. The interactive nature of this game also makes it an exciting tool to share in a poster session, allowing the researcher to share this work in a hands-on fashion with fellow attendees.

Findings, Conclusions, Implications

During the session, the results of a pilot study will be available for discussion. This study, the first phase of more involved Design Based Research (Brown, 1992; Collins, 1992; Barab & Squire, 2004) project, provides 10th grade students (or other high school students involved with the relevant coursework) with up to an hour of play experience in pairs, during which the players are observed, followed by a group interview about their experience. Special attention is paid to participants' genders and their grades in mathematics and science.

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"Together we can beat this game: The prevalence of collaborative learning in educational video game play"

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Abstract: The ever-increasing popularity of video games has raised questions about their role in generating meaningful learning experiences. Despite the prevalence of digital media and social networking, relatively little research has been conducted on the presence and benefits of social learning in educational video games. Preliminary studies suggest that by facilitating interactive and engaging experiences, video games offer opportunities for players to engage in problem-solving, socialization, and most importantly, collaborative learning.

As the doctor began to extract the ectoderm cells that he had painstakingly cultured for today's spinal surgery he cringed at the idea of repeating this procedure again. *"You're going to kill those cells*," said his assistant. *"Shut up,"* replied the doctor, *"I know what I'm doing."* Just then the cells began to decompose. *"See,"* affirmed his assistant, *"I told you". "It's fine,"* sighed the doctor *"You were right, next time we'll try it your way."*

While this vignette may sound at first like an exchange between two physicians, it is actually a conversation between two high school students playing Progenitor X, an educational video game focused on regenerative biology concepts. Interactions of this nature are commonplace and frequently written off as a casual disagreement amongst game players. However, these conversations provide evidence of a rich collaborative learning experience taking place during video game play. Unlike other educational delivery systems, video games offer the opportunity to construct learning experiences through a combination of social interactions and immersive gameplay.

Early research has indicated that some games are effective at facilitating learning gains (Squire, 2004) but the source of these gains is unknown. Studies suggest the primary benefit of educational gaming is purely motivational. While content knowledge has served as the benchmark for assessing the effectiveness of learning from video games. Current findings suggest that a tremendous amount of experiential learning is taking place unbeknownst to the player or observer. This aspect of collaborative learning could have far reaching implications for future game development, but has thus far gone largely unobserved.

There have been myriad applications of digital media for creating communities of gamers in online networks, but these have largely been viewed as serving a recreational function. Collaborative learning, on the other hand, has been studied extensively and shown to result in content learning gains by as much as 50% in formal educational settings (Johnson et al, 1981). Despite widespread acceptance of the benefits of collaborative learning and the nature of games as a catalyst for social interaction, relatively little research has been conducted on the benefits of video games towards stimulating collaborative learning (Amory, 2007). While the focus of video game effectiveness has centered largely on individual content learning, Foko asserts that games provide the context and information to accomplish a task; yet it is the social interactions between peers and technology that result in new understanding (Foko, 2006). It has been determined that the observational recording of gameplay provides a unique and naturalistic approach to observing collaborative learning without hindering experimentation of the subject.

The CyberSTEM games study focuses on collaborative learning within a suite of educational STEM-focused games developed by the Educational Research Integrated Area (ERIA) under the direction of Dr. Kurt Squire. Rockman et al (REA), an independent research and evaluation company is utilizing a multi-method approach to study social interaction and problem solving during game play. To date, REA has observed 28 peer-peer dyads playing Progenitor X. These dyads were recorded via webcam and screen capture software to observe social interactions and conversations off-screen while simultaneously recording their activities on-screen as they navigated through various game activities. Instances of collaborative discussion including shared problem solving, providing and requesting help, delivering praise, as well as task switching and player conflicts over controls have been recorded and coded for the purposes of observing collaborative learning patterns within gameplay. These recordings were supplemented with pre/post survey data and post-interviews which examined changes in conceptual understanding and interest as well as players' perceptions of the game experience and the benefits and drawbacks of partnered gameplay.

The following example illustrates the types of social interactions targeted for the CyberSTEM study. Here, "Amy" and "Barrett" have arrived at a place in Progenitor X where they must replicate and collect mesoderm cells. As Amy begins to collect them, Barrett reminds her that she should pay attention to the health meter, which is getting low. "The what?" she replies. "The health meter is at 24%, you're going to die!" he says. Quickly Amy selects the micropipette to collect her cells before they break down. "Yeah, we bad!" Amy exclaims in triumph. This small but significant interaction highlights how the collaborative process supports experimentation, helps point out missed or unclear objectives, guides player decisions, and ultimately provides a supportive framework that builds confidence amongst players. Without Barrett's assistance, Amy would have made more mistakes, exhibited less confidence, and increased the likelihood of quitting the game from frustration.

Preliminary survey and interview findings from those who engaged in peer-peer gameplay suggest that players found partnered game play useful in learning game instructions, overcome game challenges, and monitoring in game prompts. A majority of participants (70%, N=56) reported that playing the game with a partner made the game easier, due to their ability to share the inquiry process: "It felt a lot easier, we could discuss what's going on and how we need to finish." 75% of players reported that they had learned more as a result of having a partner present during gameplay. These findings are consistent with Gee's assertion that the benefit of video games is that they are "sites of naturally occurring, intrinsically motivated learning" (Gee, 2004) and that this learning largely takes place in the form of collaborative problem solving.

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Learning at the Seafloor, Looking at the Sky: The Relationship Between Individual Tasks and Collaborative Engagement in Two Citizen Science Projects

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Abstract: In this study, we explore the relationship between individual and collaborative learning activities as they occur in two online citizen science projects, *Seafloor Explorer* and *Planet Hunters*. Trace ethnography is suggested as a methodology suitable for investigating this relationship. Preliminary findings identify relationships between four types of activities that emerge which support individual and collaborative learning activities and participation.

Introduction

Online citizen science projects provide tools and opportunities that support public engagement in scientific research processes, often involving large data sets (Wiggins & Crowston, 2011). The activities supported by citizen science projects have the potential to lead to significant scientific discoveries and to also support participant learning opportunities (Bonney et al., 2009; Brossard, Lewenstein & Bonney, 2005; Wiggins & Crowston, 2011). Until recently, research investigating citizen science projects has conceptualized learning as a potential consequence of individual participation. Expanding on previous research, we draw on the notion of learning from Lave & Wenger's (1991) theory of legitimate peripheral participation and conceptualize learning not as an outcome, but rather as evolving forms of participation in a community of practice. We use this perspective to explore the relationship between individual and collaborative types of participation in online citizen science projects.

Methods & Findings

The research presented in this poster builds on preliminary findings generated through online participant observation (Hine, 2000) and trace ethnography (Geiger & Ribes, 2011) of two online citizen science projects from the Zooniverse (www.zooniverse.org) suite: Seafloor Explorer (SE) and Planet Hunters (PH). Trace ethnography allows us to draw attention to and use documentary traces to map both individual and collaborative forms of learning. The method compliments online participant observation as it draws attention to the visible traces left as remnants of otherwise invisible activity. Following the way that particular traces (e.g. comments, hashtags) are engaged throughout online activities can help draw attention to the ways that different activities and learning practices are related.

Based on our participant observation and analysis of documentary traces we identify four types of individual and collaborative participant activities that emerge amongst three basic features of the PH & SE projects (see ovals in Figure 1).

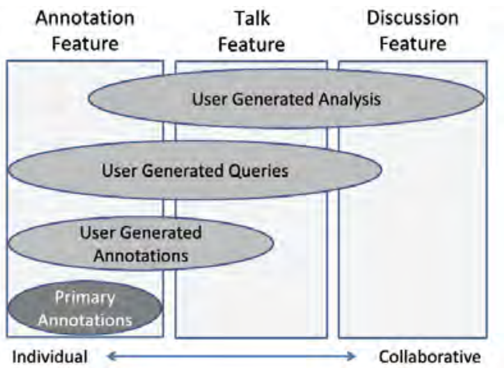
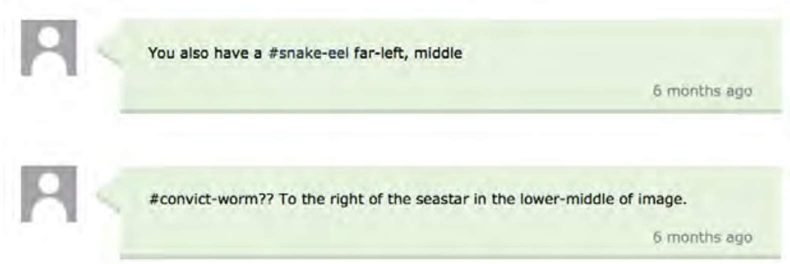


Figure 1. Participant Activity Model

Initial participants respond to prompts by the system annotation feature to annotate particular characteristics in image data, or what we describe as *primary annotation*. Participant primary annotation activities tend to be individual activities, producing individual annotations that are then aggregated and used by scientists in subsequent analyses that fulfill the primary scientific goals of individual projects. As participants become more familiar with the projects, they may begin to engage in *user generated annotation* and *user generated queries* practices. These two practices go beyond the primary annotation goal of the citizen science projects and when enacted, often represent more collaborative activities. Participants with extensive experience with the projects may also begin to engage in advanced conversations and collaborations with other participants about the data, or what we refer to as *user generated analysis*. During each of the four activities participants can leave various types of traces of their engagement. Participant traces can take many forms. For example, they can be comments connected to specific image data objects or self-curated image data collections to name a few. Examining the activities that emerge around one particular type of trace, a hashtag, highlight the connections between individual and collaborative learning within the two projects. In SE & PH, hashtags are used to emphasize the presence of characteristics or properties within individual image data objects (see Example 1).

Example 1. Species Identification Hashtag (SE)



In the above example, the hashtags are related to individual and collaborative practices of *user generated annotation, user generated queries, and user generated analysis* activities. The #snake-eel hashtag left by Participant 1 is an example of an individual act of species identification (*user generated annotation*), but the hashtag is also presented as a scaffold to assist Participant 2 in subsequent species identification. Participant 2's #convict-worm hashtag draws attention to an image data characteristic and also prompts collaborative feedback (*user generated queries*) in identifying potential species present. Once created, both hashtags are aggregated by the SE system, creating keyword collections of images with comments including the same hashtag names. By contributing the #convict-worm hashtag to the comment, the referent image is automatically included in a searchable collection of all images containing potential convict worm candidates. This is important in the SE project, because this links Participant 2's activity to the larger collaborative activity prompted by the project science team moderators of identifying a potentially new species called a convict worm (*user generated analysis*).

Based on our Participant Activity Model of participation in the PH & SE projects we find that participants engage in more collaborative activities as they move toward sustained participation in the two projects. Following the traces of hashtag activity around one instance of hashtagging allows us to begin exploring the dynamic and complex relationships between different levels of individual and collaborative learning and participation enacted within participant trajectories. Researchers interested in studying online learning activities may benefit from incorporating trace ethnography into their work as it provides a way to identify and understand the interconnections amongst various types and levels of learning that may otherwise be invisible in online environments

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Dynamic of interaction among actors mediated by the visibility in an online community, what's up with…?

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Abstract: This research aims to describe the behavior of a virtual learning community in relation to the process of knowledge building and collaborative learning from a strategy based on the pedagogical use of the visibility of academic production. The research environment is configured as two courses of Manuela Beltran University supported on the platform VirtualNet 2.0.

Introduction

The implementation of ICT in education is increasing the didactic and pedagogic challenges in teacher and students; the setting of learning environment supported by computer requires a detailed planning to ensure a good learning process using the available resources. It also requires making conscience about the configuration of a community with a specific organization to learn together a special topic. In this sense, to consider the collaborative dynamic and knowledge building process in relation with the visibility is a focus on interest with the perspective to generate new strategies for the pedagogical experience. Thus, this project develops a scientific study about visibility of academic production of students and relationships with collaborative learning and knowledge building.

Literature Review

From a reticular look, social phenomena, Prada (2005) contribute to the creation of a vision about of knowledge network and its relation with innovation community. The knowledge networks can be a powerful strategic tool that increases the innovation and learning. Brighenti (2010) elaborates the concept of visibility as a general category for social theory and social research. He also describes the approaches or disciplines in relation with this project, in specific cultural and media studies, science and technology studies, sociology and identity studies. Wasserman and Faust (1994) propose a model graph theory with application in social context, from there, this project takes the concept of "node" understood as an actor as a member of the learning community, "connection" understood as the interaction that occurs among actors. Bossalasco et al (2009) set learning process as the emerge result the interaction into learning content, the subject to guide and subject to learn, which permits the knowledge management. Respect Onrubia (2005) analyze the process and consider two types of representations, the meaning of learning content and the sense that have learned.

Research objectives and Methodology

The goal in this research is to describe the dynamic of the online community in relation with collaborative learning and knowledge building from a strategic based in pedagogical use of visibility of the academic production. As sample this project has two groups of the Virtual Unit of Manuela Beltran University in Colombia, each group has approximately 160 students. The only different between the two groups (experimental and comparison) is the implementation of didactic strategy based in pedagogical use of visibility. In this since, the research interest is established by the incident of the pedagogical use of the visibility in collaborative learning and knowledge building.

Results

The presentation of the results intended to illustrate the behavior of the three categories of analysis. In the experimental group, it was tested the activities based on visibility strategic. The analysis and monitoring of the activities permitted to seen: 1) the principal effect of the comments was because of the teacher indicates it, 2) the comments have only agree and disagree level, 3) the publications of academics products generated that the comments were incorporated in the final products. 4) There is a strong influence of the first publication on the academic production of the other members of the group, no important if this doesn´t have the requirements. 5) A significant number of students involved on the closing date. 6) Challenger tasks generate more interest. 7) When the answers of comments were distant to the date of publication the student generated low motivation to conform group of work. 8) The success of the strategic depends on the level of recognition that students have used the tool. 9) It is not only important to make public the relevant academic production, it is very important to make visibility management for obtaining better results.

To collect the necessary data to represent the collaborative activity proceeded to design an instrument named "Poll of interaction", which has enabled collaborative data collection activities developed. Figure 1 is a compilation of the first 4 graphs of activities, this shows the collaboration behavior form the activity of visibility, the main results are in activities 1 and 4, the explanation is given since the incidence of visibility strategy, in activities 2 and 3 the visibility strategy was not very strong in its configuration and the results show it.

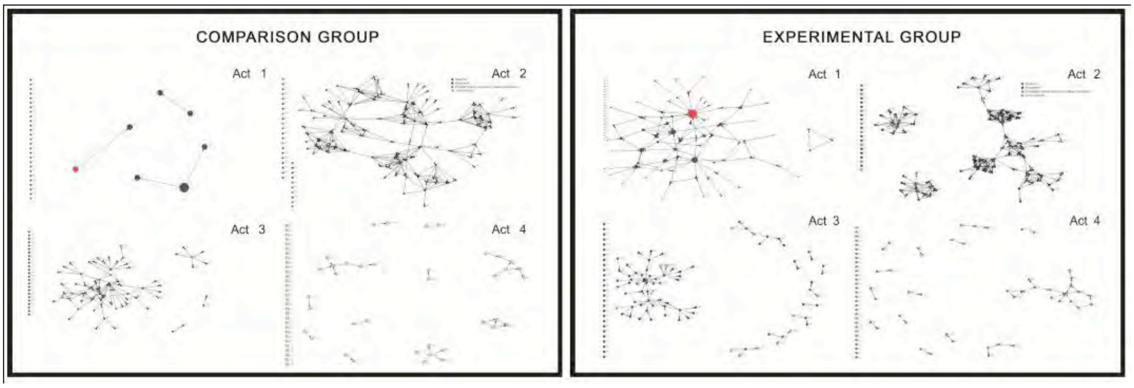

Figure 1. Dynamic of collaboration

In the case of the caparison group knowledge building process is relevant only the communication category, through the expression of ideas between student-teacher and use of resources, the academic production is oriented from the instruction. Regarding the quality of the production, a marked difference is evident. In the experimental group the effect of publishing academic products establish interaction in the moment to make visible, it enables students independently improve the quality of academic production, taking the contribution made by their peers and the teacher.

Discussion and conclusions

An element of this discussion is the behavior of pedagogic strategic, Brighenti (2010) develops a discussion around the visual and visible. In this research it is understood as the public and the visible, with this context it is possible to say that just to make public an academic product does not generates the effects of the visibility, reaching this level require that the pedagogic strategic ensures the interaction between actor and academic production to move from the public to the visible. Reaching the state of visibility described above takes up two approaches, Clifford (1963) regarding the impact of visibility from a dynamic educational, 1) *positive visibility* as the ideal state actor participation, generating constructive contributions to meeting the objectives of academic activities, and 2) *negative visibility* as a incidence of distractions presented for agreement and understanding of a group to reach the fulfillment of a goal. So is that part of the potentials are presented as forms that allow the actor to establish relationships with others and with the resources that are set in the virtual environment, such as the ability to contribute to the production of other, seeking to strengthen it and complement it to improve its quality. In that sense, the knowledge building that would be given from the Hill (2010) poses as the "relationship of a group of individuals (community) with a common, with a technological object", which is set from the virtual learning environment.

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Productive Subjective Failure in a Learning Community: Process of Explicating and Negotiating Norms

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Abstract: This paper presents a case study of an exemplary blended graduate classroom learning community that showed students taking responsibility over their own collaborative learning. Specifically, the group went through a stage of productive subjective failure before intentionally deciding to explicate and negotiate their own group norms. This transition saw a marked increase in collaboration among group members. Using a micro-genetic interpretive approach, we analyzed the stages of group development that led to this outcome. Our findings indicate that the process of explicating and negotiating norms (PENN) was the climactic event whereby the group transformed their responsibility and collaborative learning behavior. We discuss the implications of our findings, which we believe inform both theory and design of productive failure in CSCL.

Introduction

Productive failure (PF) has generated a great deal of interest by the Learning Sciences community in recent years, offering a new prism to examine learning. As research on PF is still maturing, there has been a call to extend the study of it to different contexts and content areas (Kapur & Kinzer, 2009). One of these areas which is in need of further development has to do with a foundational concept in CSCL: learning communities (LCs), which has a focus on the socio-cultural aspects of learning (Brown, Collins & Duguid, 1989). Bringing PF and LCs together is not only an interesting challenge, but an important bridge to build so that two areas of research can be better connected.

Research on PF has based its definition of failure measured against a canonical standard (Kapur, 2008; Kapur & Kinzer, 2009; Kapur & Bielaczyc, 2012), making it reasonable that attempts that fall short of meeting the standard may still be rewarding, so long as learners engage in sustained, divergent thinking. If the standard upon which the concept of failure is altered to a subjective one, in contrast, a different explanation for the hidden efficacy of failure may result. A subjective interpretation of failure means that it is the appearance of failure which defines the term, regardless of what external standard is reached. Given this definition, subjective failure involves an interpretation of a particular situation or problem. In LCs, the way the group perceives their failure and the productivity that results becomes the essential issue.

The differing standards upon which failure is based also leads to variation in the way that failure is induced. In canonically-based failure, ill-structured problems are given so that there are many problem parameters, along with several other characteristics, designed to make the problem complex (Kapur, 2008). While the level of the learner or group is taken into consideration so that the problem is outside the relevant zone of proximal development, the problem itself is at the center of failure inducement. In subjective failure in LCs, in contrast, the group is at the center of failure inducement. While the complexity of the problem is still important, there are different considerations for how to induce the failure. These can include interventions that affect group cohesiveness, social norms and other aspects of group dynamics.

Methods

In this paper, we present a case study of an exemplary blended graduate learning sciences course that was developed over seven years as part of the Educational Technologies Graduate Program at the University of Haifa (UH), Israel. As part of the course (CATELT), interventions that induced subjective group failure were part of the design. We micro-genetically analyzed the discourse of members of the course to examine individual and group development, with the aim of providing fine-grained evidence of group productive subjective failure in our environment.

Findings

The second stage of CATELT had a subjective failure effect as a result of exposing students to the epistemic reality of being part of a technology-enhanced classroom learning community. A group feeling of stress manifested over the quantity (i.e., workload) and quality (i.e., type of interaction) of contributions entailed as part of such practice. This ultimately led to a group perception of failure.

There was a learner-centeredness in the design that contributed to students' experience of failure. This was based on the reflective activities, where students had to engage in a continual process, throughout the semester, to develop their own narratives about who they were as learners. This was done by having students relate their own repertoire of previous experiences from their personal lives to the collaborative experiences they were having.

By week seven (out of thirteen), the group had shown repeated signs of tension and conflict. A string of events appeared to be a climactic turning point for the group, based on a subjective perception of failure.

> Pheobe: I had enough - this topic of the group. You always present it like we are here for you [referring to another student], but it is like a school of sharks during the week, and I think also in the assignment of the week, and last week.

Pheobe's comment showed that the way the group was behaving was unacceptable to her. Her extreme metaphor of the sharks appeared to represent a climax for the group, which saw a turning point in their discourse from complaining to recognizing that they failed as a group. In the ensuing dialogue, the group explicitly discussed the fact that something was wrong in the way they were working together. This was summarized by one student:

> Patricia: On Wednesday, it became clear to me that I wasn't alone - that a few others thought that there wasn't collaboration and that it is not possible to create collaboration in this way. Something else is needed.

The onset of the third stage in CATELT was marked by the group assuming responsibility over explicating and negotiating their own norms (PENN). This came in the context of the course design, which afforded this opportunity both during ftf sessions and in the online collaborative Wiki environment. The productivity that ensued resulted from their perception of failure, making the PENN an example that the subjective perception of failure in stage two was productive.

Once the group reached a perception of failure, the discourse changed to one that was focused on taking responsibility over the PENN. Two students requested to lead a special activity that was endorsed by the group and the instructors. The students broke down into small work groups, and then engaged in a PENN in the learning community. During the subsequent online interaction, the students requested the instructors to add the development of the Wiki norms page to the weekly online assignment. For the first time in the semester, the students also edited the weekly assignments page, showing they were taking responsibility over their collaborative practices. The entire group was thereafter very active in further explicating and negotiating their own norms, as well as collaborating more meaningfully.

Discussion and Conclusion

Our research is at the beginning stages of what we hope can make a contribution to the concept of productive failure. Our learning community approach, which considers subjective standards of failure, calls for a different standard upon which to define failure, a different way to induce it, and a different methodology to research the phenomenon. The idea that there could be hidden efficacy in the perception of failure by a group, and not just in failing against a conventional standard by individuals, suggests a whole host of considerations that extend the meaning of the concept and may make it more applicable to the learning community approach. We hope to extend our exploration of this group process involved in inducing failure in future CSCL research.

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Sociomathematical participation: Participatory culture and mathematics pre-service teacher education

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Abstract: Despite intersections between discipline-specific mathematics content and classroom social norms and learning practices, little research documents relations between social and mathematical activity as examined through social and digital media. Drawing upon complementary theoretical perspectives concerning social media and mathematical activity, this research investigated the participatory culture of mathematics pre-service teachers. Data suggest multiple social practices, including collective intelligence, distributed cognition, and appropriation, that were exhibited through a discursive classroom activity structure.

Introduction

Scholars are attentive to intersections among engagement with discipline-specific mathematics content and the social norms and learning practices of classrooms (White & Brady, 2010; Yackel & Cobb, 1996). Advances in educational technology have afforded researchers software designs and network-based devices that further delineate relationships between social and mathematical activity (e.g. Roschelle, Knudsen, & Hegedus, 2010; White & Pea, 2011). While many technologies and activities are designed to support students' familiarity with mathematics content, prior research has seldom documented how relations between social and mathematical activity may be examined through behaviors, media, and technology that are primarily social and participatory.

Participatory Culture and Mathematics Education

Digital and social media are changing classroom interactions. One significant change concerns participatory culture, or interactive and social practices with "relatively low barriers to artistic expression and civic engagement, strong support for creating and sharing one's creations, and some type of informal mentorship" (Jenkins, Clinton, Purushotma, Robison, & Weigel, 2006, p. 3). Participatory culture has fostered new digital literacies and impacted classroom teaching and learning (Gee, 2007; Lankshear & Knobel, 2009). Yet mathematics teachers often only use technology to model examples for students who then complete drill exercises (Niess et al., 2009). Within mathematics teacher education, little research examines social practices associated with participatory culture. With early career and pre-service teachers "digitally able" (Starkey, 2010), those enrolling in teacher education programs are likely to consider participatory culture "a commonplace way of socializing and learning" (Davidson & Goldberg, 2009, p. 13). This research investigated pre-service teacher learning at the intersection of participatory culture and mathematics education.

Theoretical Perspectives

This research drew upon theoretical perspectives about participatory culture, mathematical activity, and social practice. Participatory culture(s) are locations and patterns of social interaction and skill developed through collaboration and networking (Jenkins et al., 2006). Participatory culture includes membership "affiliations" in communities with similar interests, creative forms of media "expressions," "collective problem-solving" generating new knowledge, and "circulations" among media networks. Corresponding skills include play, performance, simulation, appropriation, multitasking, distributed cognition, collective intelligence, judgment, transmedia navigation, and networking, and negotiation. Concerning mathematics and social practice, learning norms can complement social practices. Yackel and Cobb (1996) distinguish sociomathematical norms as those aspects of mathematics discussions that are specific to students' understanding of mathematics. In contrast to purely social norms, a sociomathematical norm establishes an understanding for what counts as an acceptable mathematical explanation within a classroom. This research asked: What pre-service teacher participatory culture social practices and digital media representations correlate to mathematics education discussions?

Methods

This research concerned a classroom activity structure developed to examine the intersection of pre-service mathematics teachers (n=21) participatory culture with mathematics activity. Data were collected from online discussions about course texts. Six pre-service teacher groups convened weekly to answer discussion questions and create digital media representations. Data were analyzed to examine what social practices and digital media representations correlated to online discussions about mathematics, and if these instances suggest sociomathematical norms. A deductive coding scheme was created based upon eleven "new literacy skills" defined by Jenkins and colleagues (2006) (play, performance, simulation, appropriation, multitasking, distributed cognition, collective intelligence, judgment, transmedia navigation, networking, negotiation); for example, the "collective intelligence" code was applied when pre-service teachers displayed an ability to pool knowledge and compare notes with others towards a common goal, "distributed cognition" when interacting with tools that expanded mental capabilities, "appropriation" when meaningfully sampling and remixing media content; and "transmedia navigation" when following information across multiple modalities.

Findings

Pre-service teachers generated 24 discussion representations about mathematics education. 14 were wiki-based; seven utilized the wiki-based course website to create text only representations, four included text and digital images, two multiple linked wiki pages with media, and one with embedded video. Pre-service teachers also created three digital media presentations hosted elsewhere online but embedded within the course wiki website, two blogs, one podcast, and four representations that featured other media. The 24 discussion representations included 42 instances of seven participatory culture social practices. Collective intelligence was exhibited in 15 instances, distributed cognition in nine, and appropriation in seven. Four social practices were not exhibited: performance, simulation, multitasking, and judgment. Multiple practices were used across all groups. Four groups exhibited both distributed cognition and collective intelligence in eight representations. For example, Group 1 exhibited distributed cognition and collective intelligence in three of four representations. Nearly one-third (seven of 24) representations exhibited at least three participatory culture practices, including three representations created by Group 1, and one each created by Groups 2, 3, and 6. This subset of representations included five of the eight pairings of distributed cognition and collective intelligence, and all instances of networking.

Conclusion

This research suggests that participatory culture practices, particularly collective intelligence, distributive cognition, and appropriation, were exhibited when pre-service teachers discussed and created representations about their developing knowledge of mathematics and mathematics education practices. With blended and online learning environments prevalent within higher and teacher education, the classroom activity structure described in this study may be useful within education settings that span multiple learning spaces and modalities to leverage students' tacit familiarity with digital and social media. For mathematics education researchers, these findings suggest that technologies and social practices associated with participatory culture might help establish sociomathematical norms, expanding the repertoire of behaviors and locations available for teaching mathematics.

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Dissecting Video Discussions and Coordination Strategies

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Abstract: Video technology has become one of the most powerful instructional techniques in modern E-learning. In this paper, we report a classroom study on using online video discussions with various coordination strategies. We not only reconfirmed that video-mediated conversations with coordination strategies were effective and aligned with the literature, but also investigated the pattern differences of the coordination strategies on students' engagement with online video discussions.

Introduction

The use of web based video technologies in education has increased dramatically in the past decade. These applications are being adopted in an increasing number of educational contexts, including traditional face-to-face classes, teacher blogs, school websites and distance learning courses. Benefits of using web-based video technologies have been reported. They range from a) the opportunity to manipulate and interpret principles and processes situated in the video b) linking content and concepts to everyday experience c) self evaluating, modifying, testing and revising one's own knowledge, d) learning from errors, evolving deep understanding from initially flawed beliefs (Hannafin, et al., 1999) and e) increasing student motivation (Koumi, 2006). One of the biggest challenges in current online web-based video publishing and commenting tools is encouraging persistent collaboration and active knowledge construction in distributed environments (Soller, et al., 2005). However, most online video collaboration tools only support posting comments on a discussion board that reference the entire video instead of specific points within the video. This makes it difficult to understand other users' comments due to the absence of context in the video and/or the conversation thread. Moreover, the task of facilitation in these applications is difficult because 1) there is no facilitator, 2) the discussions are open to everyone, and 3) there are no access/privacy controls to build a discussion for a particular group of people. In many cases the purposes of the discussions and the expectations of the participants are not clear. This makes these applications inappropriate for having a quality discussion, giving rise to inappropriate comments, unhealthy interactions and uncontrolled conflicts in the community.

In this work, we study an interactive, collaborative online video discussion tool called Vialogues. Vialogues is a video discussion tool that leverages videos for learning by adding group interaction as part of the viewing experience. Users can create "Vialogues", which are focused discussion environments that include comments time-coded to different parts of the video. The design and case studies have been presented in (Agarwala et al., 2012). In this paper, we design a semester long study to explore the effects of various coordination strategies on students' discussion/participation patterns.

Vialogues

Vialogues allows users to comment directly on specific portions of a video, rather than posting comments in discussion board fashion which reference the entire video. The video and threaded discussions are organized on the left and right side of the screen respectively (Figure 1). All the comments are time coded to a specific point in the video. They are mutually referenced and represented in the visualization, which addresses the problem in many existing video-discussion tools where users are often unable to understand others' comments due to the absence of context in the video and/or conversation threads. Vialogues provides a set of pedagogical tools to assist teachers in flexibly designing and monitoring learning activities as well as receiving feedback from students based on instructional needs. Teachers can either ask survey questions, or devise poll questions at any given moment in the video. Vialogues are also embedded with privacy control for moderators to effectively control the quality of their discussion or tailor a discussion for an intended group of students. Vialogues are also embeddable for external systems (i.e. personal blogs, learning management systems etc). It increases flexibility in diverse settings to adapt to the relevant social, cultural, and pedagogical contexts.

Figure 1. Vialogues, http://vialogues.com

Evaluation & Discussions

To explore the effects of various coordination strategies on students' discussion/participation patterns, we set up 4 coordination strategies used throughout the semester in a graduate course entitled "Sociology of Online Learning". For each class meeting, a set of readings and a Vialogue are assigned in the syllabus. Students are advised to read the material in advance and encouraged to watch and discuss it on the assigned Vialogues. The 4 coordination strategies are: 1) Natural discussion: the instructor does not intervene in the student discussions. 2) Pre-structured discussion: instructor provides guidelines for the discussion but does not intervene in the discussion process. This is done by having the instructor pre-plant the questions at different points of the video. 3) Coordinated discussion: the discussion is not pre-structured but the instructor coordinates student discussions by responding to students' questions about the video, providing extended resources based on the discussions, further prompting students to think and engage in the material. 4) Pre-structured and coordinated discussion (Mixed): the discussion is both pre-structured and coordinated by the instructor. Based on (Salmon, 2000), we hypothesize that coordinated and mixed conditions would achieve better learning effects, measured in terms of discussion quality and quantity.

We found that with coordination strategies, students were more engaged in the video discussions. Students elaborated more for all three coordinated discussion strategies. This was as predicted, as the literature shows that providing moderation during collaboration encourages more contribution. Our major goal in this study is to understand how the coordination strategies work by analyzing the patterns of differences of students' engagement. For 3) coordinated & 4) mixed conditions, the discussion lifetime was longer than the weekly meeting of the class, regardless of the length of the video. On the other hand, discussions using 1) natural & 2) pre-structured coordination happened only during the week of the class in which the material was assigned. For 2) pre-structured discussions, the coordination still had influence to some extent. However, the whole discussion was not coordinated in an *engaging* way. Therefore, it did not yield a continuum discussion over time. Is a longer discussion better or shorter one is better? We have to evaluate the content of the discussions.

To assess the discussion quality, we applied a linguistic text analysis package, LIWC (Pennebaker et al., 2007), to gauge students' emotions, cognition and structural components based on the categories of words they used. We only considered the major psychometric categories and discarded the linguistic & personal processes. We particularly focused on the *social, affective* and *cognitive* processes. The results showed that 4) mixed coordination provided the most *social* discussion environment, while the other coordination strategies did not differ from no strategies at all. It confirmed that the mixed strategy (pre-structured and coordinated strategies combined) created the highest engagement. For *affective* processes, we found that the 4) pre-structured strategy yielded a more neutral discussion. Students showed less positive and negative emotions. The possible explanations could be the discussions were explicitly structured to begin with, so students were focused from the beginning. On the other hand, the rest of the conditions provide more room for students to explore in the discussions. For *cognitive* processes, coordination strategies 2), 3), and 4) yielded similar results to 1) a natural discussion. Thus, regardless the coordination strategy, the time-coded discussions around videos solicited a substantial amount of insight around the discussion topics.

Based on these preliminary results, in addition to reconfirming that video discussions could be successfully facilitated by appropriate moderation, the findings also revealed that a pre-structured strategy was effective for short-term focused setting. A mixed strategy was effective for long-term social settings. It boosted high social energy among users and contributed to the high engagement in the discussion. In addition, the discussion can be carried over past the assigned week of the material. Finally, a coordinated strategy successfully carried the discussion over than a regular course week. However, it did not appear to be either social or particularly focused in our observation.

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Making math learning social and familial: the promise and problems of mobile devices

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Abstract: In order for families to engage in math play, we created several mobile applications that were designed to maintain fidelity with family practices while simultaneously providing opportunities for mathematical learning. We explain our reasons for developing apps that rely on social models of play, outline design principles that emerged from research with families, and share the successes and issues that arose in field tests. While the apps provided opportunities for rich math talk in the families, the mobile platform came into conflict with mobile users' tendencies toward individual time with their devices. The results raise concerns about mobile affordances and uses as collaborative learning devices in families.

Introduction

When surveying the education technology landscape, we began to notice that a majority of apps and games for children have been designed for individual user play. With technologies such as Intelligent Tutors (Koedinger, Anderson, Hadley, & Mark, 1997) we have made great strides in creating effective learning technologies that center around the individual learner and her progression through developmentally sequenced, disciplinary-based learning activities. Our project looked beyond school-based learning, conducting research to better understand math problem solving in families, to see if there was a way to design for social learning experiences in the spaces side of school. We discovered that families engage in a great deal of problem solving together. Our project to develop math apps attempted to maintain fidelity with the social and interactive opportunities that families engaged. The goal was to have children, friends, siblings, and parents play math games together in a way that corresponded with, and drew on, the culture of the family (Martin et al. 2009). Based on this goal of finding and designing learning opportunities that would have fidelity with family practices, we undertook and started developing Go Math! iPhone apps.

We conducted basic research on families to understand what actually happened that was mathematical in the course of their daily activities. We found that math inside families was not like math in school (Esmonde et al. 2013). Mathematically relevant problem solving in families was social in nature. Math at home was connected to values and needed problem solving, and was more about accomplishing what needed to be done than it was about getting the math correct.

Learning about what mathematics looked like inside families led us to think about how to build on the families' day to day math engagements. We took our findings and created a set of design principles that would guide our development of technology for family learning (Alexander et al., 2010). Our team wanted to make sure that the app environments: 1) were driven by the situations families find themselves solving problems in, 2) promote the enjoyment of math, 3) demonstrate the value of using math, 4) be compelled by what matters to families, considering the family as a social unit, and 5) serve as a complement to the math learned at school. Because the families were often on the move and extremely busy, the environments also should take advantage of the affordances that mobiles provide. Overall, these principles were meant to cleave with, rather than contradict family life and serve as a blueprint for much of our application design work. One application that rose from this blueprint, GoRoadTrip, serves as an example of our design and the issues that we have confronted.

GoRoadTrip: Building on Basic Research and Design Principles

GoRoadTrip has evolved into a mini suite of games that families can play at home or while taking car trips. Playing games is a topic that came up often with families in how they would promote enjoyment of mathematics with their children, and something that parents valued. The scenario of a car trip also came from families who discussed how they entertained themselves while on long trips.

When we began designing GoRoadTrip, the ubiquity of cell phones among children, particularly "internet-enabled smartphones", was low. Therefore, to enhance the adoptability and reach of GoRoadTrip, we decided that, inside each game and during game play, one phone could be shared by multiple copresent players. Having a shared phone made the most sense, as it focused our designed experience on family interactions. The applications simply direct each family member to take their turn and pass the phone to another player (see Figure 1). The GoRoadTrip application not only directed the user to pass the phone but also relied on the mechanics of the game to provide good reasons to do so. For example, in *Traffic lights* users either work together or ask one user to enter a secret 3-digit number. After providing a secret number the remaining family members take turns trying to guess the number based on a history of guesses given by the family members (See Figure 2).

Figures 1 and 2. Screenshots of *Traffic lights* asking to be passed and displaying families working together.

Every time a member of the family guesses a number, feedback is given to that member about their guess. Players receive three different types of feedback on the 3 digits that they guessed. Each member of the family also though receives the feedback that other family members have gotten, which allows them to collaborate on solving the secret number. This game is inspired by both "Bagel, Pico, Firme" and Mastermind and follows our mission statement by promoting the enjoyment of math, using the affordances that the mobile provides, and serving as a complement to school.

Having built a prototype, we then conducted user tests. Initial pilot testing involved videotaping families while they used GoRoadTrip in the car. We documented that children would pass the phone around while playing the games and work together to try to solve the problems. Older siblings taught younger siblings how to play the games, and they would often collaborate both on the screen and off the screen while having discussions about the math and their possible solutions. Parents engaged enough with the students in the car that we had to include a warning not to touch the game while driving.

Data analysis indicated that the socially oriented mobile applications have both promising and troubling aspects. On the positive side, they do generate conversation and activity with math among family members. On the troubling side, children have sometimes found it difficult to get others to play with them when they are taking turns, and several have indicated that they play the games primarily against themselves. Since we began app development and the studies, patterns of mobile use in families have emerged such as the "pass back" phenomenon, where parents give the child their mobile so they can drive in peace or have a few minutes to do something else other than engage the child. We are concerned that the social requirements of our mobile apps are in conflict with the trends toward individual use. These contradictions leave learning technology designers with dilemmas to solve: if social math is possible and somewhat natural way to learn in families and mobiles are becoming ubiquitous and fitting the activities and lifestyles of families, how do we actually design opportunities for collaborative learning in consideration of people's tendencies to seek out mobile time as individual time? We hope to drive this point as well as provide more first hand evidence in our poster sessions.

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Using Social Media Behaviors to Design Language for Advancing Pedagogy and Assessment

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Abstract: As engineering education propagates into K-12 education, questions surround pedagogy, curriculum, and assessment and instructors are challenged when it comes to measuring and documenting learning. This project uses captured video observations to model social media interaction behaviors and use them as the infrastructure to design a text messaging/IM language for classroom use between students and teachers. The language will serve as both a pedagogical and assessment tool.

Introduction and Theoretical Framework

Engineering education integrates pedagogical techniques from technology education, science education and design education. The studio critique and design notebook are two components of design education employed in an applied science/engineering summer course for rising high school seniors. The dialogue between student and design notebook, with each other and teacher create a rich medium for evaluating student understanding (Svarovsky & Shaffer, 2006) and can be seen as an epistemic triangle where dialogue can be analyzed because reasoning occurs (Atwood, Turnbull, & Carpendale, 2010).

Research shows that when comparing various forms of media (paper, photographs, in situ video), that students do not write down everything that might help instructions trace their rationale and thought processes. In situ video reflected evidence of valuable reflection and iterations in brainstorming sessions and studio critiques through natural verbal language that written language could not capture (Author, 2012). The natural extension of the research is to review video and take advantage of the ways youth use text messaging and IM to make communication more efficient and interactions within a class and instructor richer. Youth already use text messaging, sending up to sixty a day (Lenhart, 2012). Twitter and text-messaging tools have been shown to increase motivation to write and interactions between students (Tomita, 2009) and instant messaging (IM) is "real-time written discourse (Ferrera, Brunner, & Whittemore, 1991). Text messaging and IM allows teens to multitask (Nardi, Whittaker, & Bradner, 2000) and the delay in IM and text-messaging allows space teachers to respond and react to questions or ideas. Use of such a tool based on IM and text-messaging offers a synchronous, written communication that is culturally natural which that has a shorter turnaround time than grading journals or teachers watching video to youth.

If we viewed each individual classroom as a community of practice (Wenger, 1998), knowledge and communication can be created within the community if students and teachers were given an infrastructure for communication and documentation. Rather than creating a language tool without student participation and superimposing it onto their natural tendencies, we use collected data reflecting their natural communication patterns and behavior to increase authenticity and reduce the disconnect between the language that instructors want students to use and the language students actually use.

Method and Preliminary Results

Twenty-two low SES public high school students participated in a four-year college preparation program for disadvantaged students. These students are expected to be the first generation within their family to attend a four-year university. The students are first generation immigrants from Africa, the Caribbean, and South America. Most of them speak English, a native language, and a cultural dialect and come from homes where English is not the primary language. At the time the data was collected, students were rising seniors.

Students matriculated from multiple cultural and language backgrounds, so switching between multiple languages occurred. Because this group of students had been together socially and academically for approximately four years, they reflected a community of practice because of their shared mission, goal of college attendance, and indoctrination of the programs' beliefs. There was non-academic language because the class was conducted as a reality show and students were relaxed and comfortable with ongoing video, but non-academic language is not the concern of the research.

This video data is analyzed using grounded theory (Strauss & Corbin, 1990) to identify communication patterns and common language features. The types of video scenes analyzed include brainstorming sessions, small group work sessions, and final presentations. Themes were generated from coding that form the categories of interactions that happen between students. Initial coding results are shown (see Table 1) and we expect to broaden the interaction categories as we validate these codes on new video clips in rounds two and three. Some of the categories have subcategories because there were examples of more than one type. Questions occurred many times but had different purposes and motivation.

Table 1: Categories of Interaction Behaviors

Interaction Behavior	Type
Question	Why interrogative, how interrogative, redirect question, clarifying question, reconsider question
Mind change	
Reasoning	Layering idea (broadens idea), deepening idea (digs into idea), constraint, consideration,
Identify problem	
Decision	Confirmation, selection from options, Completion
Choice	Binary selection, range
Action plan	
Fix	A response
Checklist	
Lightbulb recollection	
Uncertainty	I don't know, I don't remember
Cancel	"Nevermind"

Conclusion

The results of this study will offer researchers and educators interested in pedagogy and assessment an efficient pathway for communication, interaction, and observation of classroom interactions using a cultural language shared by both. The experience and success of students using a cultural language in an environment where cultural language is often unacceptable can be compared to students who are forced to continue to only express their thinking using acceptable language. When the categories are defined and later tested, the data can then be used to create an application, design rationale tool, or digital design journal for use in K-12 settings that allows instructors to see process knowledge. If the language is tested and proven as a valid medium for pedagogy and assessment, it can be adjusted for application beyond STEM courses and formal classroom settings. The next steps beyond attaining access to process knowledge would be to identify ways to measure change and validate those changes in overall assessment of student knowledge.

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Transferring CSCL findings to face-to-face teacher practice

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Abstract: Collaborative learning is a well-researched instructional approach that is highly effective and often superior to individual learning. However, the fruitfulness of the collaboration depends on the quality of the student interaction. What do teachers need to know to monitor the quality of the group interactions? We developed a model describing teachers' competencies for Implementing Collaborative Learning in Mathematics (ICLM). We illustrate here how CSCL findings may inform monitoring, one major facet of teachers' ICLM competencies.

Collaborative learning is a well-researched instructional approach whose effectiveness is well established. However, this effect depends on the quality of the student interaction (Dillenbourg, Baker, Blaye, & O'Malley, 1996). Teachers play an essential role in ensuring that the student interaction in the classroom is beneficial for learning. In the computer-supported collaborative learning (CSCL) literature, methods for designing, monitoring, and supporting collaborative learning with computer-based tools are well-described. In face-to-face teacher practice, teachers also need guidance for monitoring the ongoing student interaction similar to tools in CSCL environments. We present a theoretical model describing teachers' competencies for Implementing Collaborative Learning in Mathematics (ICLM) and illustrate how CSCL findings may be beneficial for teacher practice, especially for monitoring student interactions. While we chose to situate the ICLM model in mathematics as the learning domain, the model may be transferred to other domains as well.

Theoretical framework

The Implementing Collaborative Learning in Mathematics (ICLM) model is based on the meta-cognitive framework of teacher practice by Artzt and Armour-Thomas (1998) that describes teaching in analogy to a cognitive process of solving a problem in three phases: a pre-active phase, an inter-active phase, and a post-active phase. The model describes which competencies are needed to successfully implement collaborative learning in the respective phases. While *planning* is part of the pre-active phase, *monitoring* and *supporting* take place during the inter-active phase. Additionally, an important element of the inter-active phase is *consolidating* the groups' work. Finally, in a post-active phase, *reflection* is of vital importance in helping teachers to improve the planning of collaborative learning situations in particular. In the current paper we focus on one facet of the model in particular, that is, monitoring.

While students are collaborating, the teacher has to monitor how they are working together to ensure the fruitfulness of the collaboration and support the students if necessary. In the CSCL literature, monitoring students' interactions is often supported by a teacher cockpit that visualizes live data from the interaction processes (Roschelle, Rafanan, Estrella, Nussbaum, & Claro, 2009), for instance the different amounts of oral and written contributions. The cognitive algebra tutor (Koedinger, 1998) that checks for students' errors in finding the solution for the mathematics problem at hand can be extended by an additional feature that allows for collaborative working on the cognitive tutor. This collaborative extension helps to identify how students behave in different roles, for instance as a tutor and tutee (Walker, Rummel, & Koedinger, 2009).

Teachers in the classroom especially face the challenge of monitoring the interaction processes taking place in several groups at the same time. Group awareness tools such as the "Lantern" (Dillenbourg & Jermann, 2010) are a simple implementation of a teacher cockpit that works for face-to-face collaborative learning. The different colors of the "Lanterns" give the teacher an overview of the collaborative working phases the different groups in the classroom are currently involved in and whether they need help.

While other sophisticated technological solutions that monitor how students are working together are not so easily implemented in face-to-face collaborative learning, the indicators underlying successful collaboration can be transferred. For instance, Meier, Rummel, and Spada (2007) developed a rating scheme to evaluate the collaboration of dyads in a computer-supported learning environment on multiple dimensions. Their indicators of successful computer-supported collaborative behaviors may help teachers to observe face-to-face interactions in the classroom as well, for instance whether students engage in argumentations or explanations of ideas. We thus propose that teachers could use checklists with behavioral indicators targeting three dimensions of collaborative learning adapted from Meier and colleagues, namely collaborative, cognitive, and meta-cognitive activity. A successful collaboration for instance requires that all students are actively engaged and share information (Johnson & Johnson, 1998). Visible cognitive activities include asking targeted questions and giving elaborated explanations (Webb, 1989). Meta-cognitive activities are indicated by comprehension monitoring and checking for errors (Bannert, 2003). Teachers using such a checklist, based on indicators of fruitful collaborative learning behavior described by the CSCL literature, may find it easier to observe these relevant behaviors and not be distracted by aspects of the collaboration that are less determining for its learning success.

Conclusion

We aimed to illustrate how CSCL findings targeting monitoring of student interactions may be informative for teacher practice in face-to-face settings. We developed a theoretical model describing the ICLM competencies, planning, monitoring, supporting, consolidating, and reflecting collaborative learning. We stressed the monitoring facet here because it is essential to assess the quality of the groups' interaction and their progress in order to identify suboptimal collaborative, cognitive, and meta-cognitive activity. When suboptimal activity in a student interaction is identified, for example insufficient explanations among students, the teacher may choose to support the student interaction, which is also an important competence teachers should have to ensure a fruitful collaboration. Our theoretical model serves as a base for developing a tool to assess these competencies and for designing a training for teacher students. The teacher students learn to use checklists of fruitful collaborative behavior for observing student interactions and we are interested to see how this training affects the teacher students' monitoring competency.

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Learning About Ecosystems Through Collaborative Augmented Reality Experiences

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Abstract: EcoMOBILE is a new middle school science research curriculum that blends exploration in virtual environments with augmented reality experiences in real world ecosystems. This poster presents examples from the design of EcoMOBILE activities that demonstrate affordances of augmented reality to support collaboration during and after student field trips.

EcoMOBILE (Ecosystems Mobile Outdoor Blended Immersive Learning Environment) is a middle school science curriculum that blends virtual environments in the classroom with field trips to outdoor environments infused with digital resources. EcoMOBILE includes EcoMUVE, an inquiry-based experience in which students explore immersive virtual representations of ecosystems, as well as a complementary set of learning experiences using mobile technologies with augmented reality (AR) during field trips to a real ecosystem. The AR experiences in EcoMOBILE help students to make connections between the models that underlie the virtual environment and the real world around them, through hands-on activities and visualizations that support observation and real-world data collection.

The ability to understand ecosystems is richly enhanced by experiences in real environments. Yet that experience necessarily focuses on what is visible, at that time, in that place. Ecosystem processes are often difficult for students to understand because they are invisible, spatially distributed, and take place over considerable periods of time. Augmented Reality can provide contextualized instruction; visualizations and information triggered by geo-referenced physical locations; and self-directed, self-paced interactive activities, with feedback on student actions and responses (Squire & Jan, 2007; Klopfer, 2008; Dunleavy and Dede in press).

During a field trip, each student or student pair is given a smartphone; students log in to run an EcoMOBILE app. The experience provides self-paced directions and structure, using location-based AR to guide students to specific physical settings ("hotspots"). When students come to a hotspot, interactive content pops up, including text, images, audio, video, and questions (Figure 1). Vision-based targets in the physical environment can also trigger pop-up 3D visualizations or animated models. Students may be assigned complementary roles, using a jigsaw pedagogy with each role visiting a different set of hotspots, or there might be opportunities for students to select which hotspot to visit next; in this way the activities allow for self-directed exploration, while providing context and structure through the smartphone.

Figure 1. Students using EcoMOBILE; Example hotpot.

EcoMOBILE's design includes two levels of AR experiences, customizable to specific locations and ecosystem features. The introductory experience supports students in observing their local ecosystem more deeply, drawing their attention to relationships among organisms and their environment (e.g., biotic and abiotic factors, habitats, food web), and causal interactions over time and across distance, which may happen at the microscopic or molecular level (e.g., photosynthesis). The second experience focuses on students collecting data about their local ecosystem, and making comparisons with the virtual world they explored with EcoMUVE.

Design for Collaboration

EcoMobile pilot activities included AR affordances targeted to support student collaboration:

- **Prompts for collaboration:** In some experiences students worked with an assigned partner. In others, each student followed a different path, but at a certain point, their phones directed them to a shared hotspot, and prompted sharing the observations made with someone who had different experiences (Figure 2a).
- **Roles and collaborative data**: In some experiences students were assigned to scientific roles, such as "chemist" or "physical geographer" – each role was then responsible for specific observations and data. In order to unlock the next experience, student teams needed to collaborate across roles, sharing data among teammates.
- **Sharing data in the classroom**: Post-field trip classroom activities centered on students sharing the data they had collected. In some cases, this involved plotting data such as pH or dissolved oxygen on a graph for comparison and discussion. In other cases, students collected geo-referenced photos of their observations, which were shared with the class using Google Earth (Figure 2b).

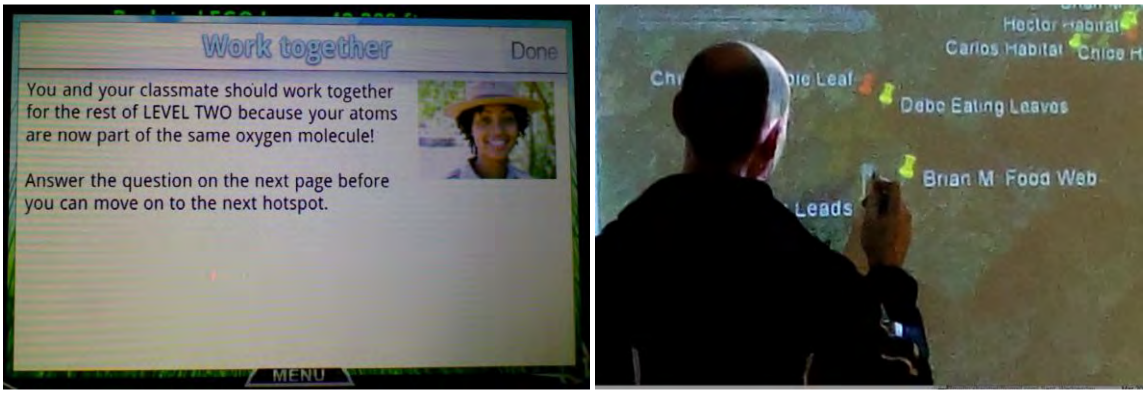

Figure 2. a) prompts for collaboration; b) sharing with Google Earth.

Preliminary results of pilot experiences with EcoMOBILE demonstrate how AR affordances can provide support for collaborative learning through interdependent game mechanisms and role-based activities.

When given the option, students naturally gravitated towards working together. One student explained that, unlike traditional activities, "we went to our friends and classmates first because this was a new experience for us and we are always kind of stuck in the classroom. Usually you go to your teacher because they know what is going on, but because this was a new experience you could go to your friend and be like I can figure this out with you."

Interviews with pilot teachers found that the smartphones promoted student interaction both with the ecosystem and with their classmates (Kamarainen et al., 2013). One educator commented, "It invited much more student on student dialogue because they had to engage together to sort of figure out things that were coming through to them on the smartphone. So it, in some ways, I thought that their dialogue probably deepened their understanding." Another teacher described how the impromptu collaborations worked well for his class: "We had kids group up at first with their friends, but then the hotspots would take them to different places, where they would then collaborate with other people who they would normally never work with. So you saw a lot of blending of 'middle school social castes,' you know, you've got the nerds and the popular kids, all working together, it really kind of leveled the playing field for everybody."

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Joint Reasoning about Gas Solubility in Water in Modified Versions of a Virtual Laboratory

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Abstract: A virtual laboratory was designed to enable students to collaboratively discover the concept of gas solubility in water at different physiological conditions. The virtual laboratory was developed through a design experiment involving three successive versions with different guiding structures. Analysis of 13 dyads' reasoning about gas solubility in water revealed that the students' problem was to understand the concept of solubility of gases. It was also observed how the guiding structures within the three different versions influenced the students' reasoning about the concept.

Virtual laboratories – digital, simulated laboratory experiments, debated and subject to methodical research – have been used for decades. It has been proposed that virtual laboratory work could have the potential to alleviate many of the problems connected with traditional hands-on experiments (Ma & Nickerson, 2006).

Within a joint development and research venture we developed a virtual laboratory (available at http://esi.stanford.edu/gasesinwater/gasesinwater1.htm). It was carried out through an iterative design experiment that included three loops of slightly altered versions of the virtual laboratory. To guide students in their collaborative discovery process, the virtual laboratory was facilitated with several scaffolds (Gijlers, Saab, & Van Joolingen, 2009; Vreman-de Olde & de Jong, 2006). A collaborative learning setting has been shown to benefit learning from animated graphics about natural dynamic phenomena (Rebetez, Bétrancourt, Sangin, & Dillenbourg, 2010). Especially in the area of computer-supported collaborative learning (CSCL), analyses of knowledge building in small groups have developed into an important methodology (Stahl, 2006).

This paper presents findings from the reasoning of 13 student pairs as they explore the solubility of gas in water at different temperatures and water salinities in a set of virtual laboratory experiments. The purpose of the study is to add to the understanding of students' collaborative construals of the concept of gas solubility in water in modified virtual laboratory environments with different guiding structures.

Methods

In the development of the virtual laboratory, a formative iterative process was followed where the design was revised and modified in three repeated cycles. Each version contained additional built-in guidance such as introduction films, gas meter, folding menu, educational texts and pop-up boxes suggesting alternative actions.
Changes of guiding structures within the virtual laboratory were based on observations, questionnaires, and interviews with teachers and students from the previous evaluation.

When performing the laboratory experiment, the students were assigned to work in pairs. From observations of the efflux of bubbles when the water is heated and shaken and when salt is added, the students were expected to draw conclusions about the dissolution of the two gases oxygen and carbon dioxide in water at different conditions. The desired learning outcome is primarily that they shall acquire the insight that higher temperature or salinity decreases gas solubility in water.

The virtual laboratory was evaluated in the spring of 2008 at four upper-secondary schools in the area of Gothenburg, Sweden and involved eight classes, totaling 180 students ages 16-19. The evaluation process included interviews, discussions with focus groups and video recordings. In order to investigate the nature of the students' reasoning, the video recordings of 13 groups discussing the virtual laboratory experiments were transcribed and analyzed. Five groups worked with the first version, four each with the second and third version of the virtual laboratory. The filmed groups were randomly selected from the four schools; they studied the same program and were assumed to be of similar abilities.

Results

In the virtual laboratory, a burst of bubbles is seen when the water is either heated or salted, indicating that less gas remains in the water. The results from the evaluation process indicated that the problem was not primarily for students to realize that warmer water contains a decreased volume of gas, but rather to understand the concept of solubility of gases in water in relation to bubbles emerging from the water. The analysis of the video data corroborated this observation but also expose dissimilarities in the students' reasoning in relation to which version of the virtual laboratory they were exploring.

Among the five groups that worked with the first version, four discovered that an increased amount of bubbles means a decreased volume of gas in water, whereas one group held an erroneous view. In terms of the concept of gas solubility in water, all five groups held the erroneous view that more bubbles leaving the water implies that more gas dissolves. It is noteworthy that the four groups that reached the insight that an increased amount of bubbles means a decreased volume of gas in water nevertheless did not discover the scientific concept of gas solubility in water. Of the four groups that worked with the second version, all made the observation that more bubbles imply a decreased volume of gas in water. All groups also reached the intended learning outcome that more bubbles imply that less gas is dissolved. It can be observed that in three groups, one of the interlocutors initially held an erroneous view, but subsequently after discussing with his/her partner became convinced about the scientific concept. The four groups that worked with the third version noticeably differ from the other nine groups in their reasoning. In these groups the students were just reading off the gas meter and declared that the volume of gas decreases when the water is heated and there was no further discussion about the concept of gas solubility in water.

Discussion

The main purpose with the design of the virtual laboratory was to provide students with resources to discover the relation between gas solubility in water and temperature. Analyses of the filmed groups reasoning disclose that the problem might not be so much that the students did not grasp that the volume of gas in water decreases when the temperature rises, but instead that they did not understand the link between the concept of solubility of a gas in water and bubbling.

Compared to traditional laboratory work, the virtual laboratory provided extra affordances in terms of guiding structures. For example, in the second version of the virtual laboratory, a film showing molecular reactions inside the soda bottle and an assignment box with educational questions was introduced. The results show that while all four groups that worked with the second version discovered the scientific concept, no one of the five group that worked with the first version did. In the four groups that worked with the third version, there were no discussions of the meaning of more bubbles in terms of the concept of gas solubility in water, whereas such discussions were frequent in the groups with the first two versions. A plausible explanation for this might be found in the fact that these four groups explored a version of the virtual laboratory that was complemented with a gas meter. It can be assumed that the gas meter, displaying the volume of gas in the water, immediately made it clear for the students that the volume of gas decreased as the temperature increased, and that this fact consequently made further discussion unnecessary.

Thus, this study indicates that the affordances of computer-simulated laboratories might to a certain extent enhance joint discovery of a scientific concept, but also that furnishing the instructional technology with too complete guidance might risk quenching students' constructive discussions and their discovery process. It is concluded that the decision about what scaffolds should be implemented must be made in relation to the students' pre-knowledge and to how much one intends them to discover by themselves.

The next development for this research is to focus on how our results can contribute to the improvement of the design of virtual laboratories and thereby complement traditional laboratory work.

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INKA-SUITE: An Integrated Test-Environment for Analyzing Chat Communication

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Abstract: This poster is related to the field of chat evaluation. First eye-tracking and its limitations in the case of constantly changing graphical user interface (like in chats) are presented. Then the INKA-SUITE that enables eye-tracking of changing graphical user interfaces is introduced.

Introduction

To evaluate the usability of an application, studies and field tests are conducted. Such usability studies are often based on eye-tracking, which records the eye movements of a test person, who usually is viewing exhibits, projection screens or displays (Duchowski, 2007). The eye movements provide information about what is viewed in what order for how long. Eye-tracking is widely used for the evaluation of user interfaces of stationary single-user systems (Shneiderman & Plaisant, 2006), web applications (Nielsen & Loranger, 2006) and in some cases also in CSCL studies (Nüssli et al., 2009).

Existing eye-tracking systems are usually limited to static content like pictures (e.g., advertisements), websites or programs. Those static contents are at the same position for all participants so that they can be easily compared with each other. For this scenario the corresponding eye-tracking applications provide a large scale of different displaying options to document the results.

However, if this area of interest is not static, but changes its size, shape or position, the evaluation becomes much more complex and requires a certain amount of manual analysis. This is especially the case in cooperative applications such as chats. In particular, the difficulty is, that you can't predict the time of change, because it is permanently caused by user input (e.g., new chat message, scrolling). So the dynamics of the area of interest (AOI) in such applications cannot be foretold. Existing eye-tracking software is therefore not suitable in this situation. They are typically limited to a subsequent definition of those dynamic AOIs, which can be a huge and fault-prone manual effort.

At this point, the own work of the research program "Informationsgestaltung in kooperativen Anwendungen (INKA)" (Design of Information in cooperative Systems, http://www.inka.fh-dortmund.de) starts. Further on, this poster presents the INKA-SUITE as an approach for the eye-tracking of dynamic AOIs (for further information see (Schlieker-Steens & Schlösser, 2012)). This software represents a solution for tracking dynamic applications, e.g. chats in fields of the CSCL as widely known from the work of the virtual math team (VMT) project (Stahl, 2011). Especially in the field of linguistics and usability questions about chat communications could be answered.

INKA-SUITE

The base for the INKA-SUITE is the connectivity to the Tobii eye-trackers established with the Tobii SDK (see http://www/tobii.com). With a direct connection between the eye-tracker gaze data stream and GUI (C# WPF), the INKA-SUITE identifies AOIs at runtime, regardless of size, shape and position. In fact, every gaze data record is complemented by the underlying GUI element, identified by names, ID's and/or references to other database tables such as chat messages or users. A subsequent manual work is eliminated and the evaluation can be started immediately. This direct identification of AOIs is providing further opportunities, which will be discussed briefly in the outlook. This profound cross-linking between analyses related functions and user software cannot be adapted by existing eye-tracking analysis software.

The INKA-SUITE is based on a three-part application:

- A server to control and manage clients
- A client application for user interaction, which is connected to an eye-tracker
- An analysis component for managing projects and analyzing the collected data

To get a customizable interface, the client does not contain a chat interface. The interface is provided by the server. This procedure is generally called as templating and offers the possibility of a simple way to perform A/B testing with different user interfaces. To control and monitor the clients, a server component is used. At that point, the templates are chosen and assignable and the status of eye-tracking for each participant can be supervised.

The analysis application processes the recorded data and is divided into three parts: Statistic, Replay and Timeline. In the Statistic tool, general information about the chat session and also about each user is presented. For example these are duration of chat, keystrokes per minute, time to first message and messages per minute.

Within the Timeline tool the entire chat session is presented on a timeline for each user (see Figure 1, left). This ensures the comparability between users (e.g., Stellmach et al., 2010). Each users shortcuts, keystrokes, chat messages and fixations are listed separately. Using annotations, important areas can be marked. The displayed output is fully dynamic and can be adapted to the current problem.

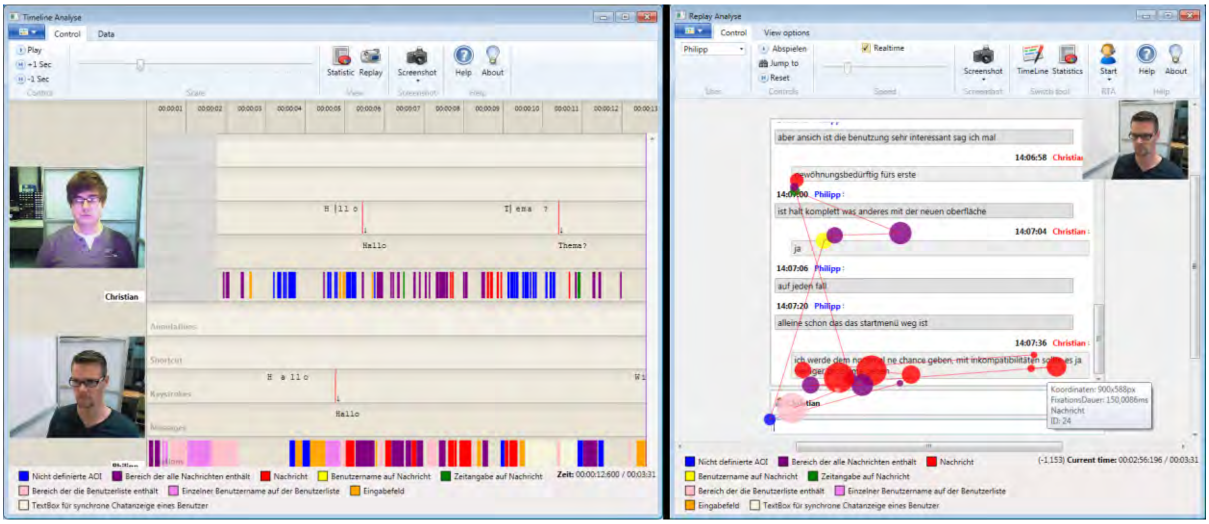

Figure 1. INKA-SUITE Timeline and Replay (Analysis tools).

For replaying the chat from the user's point of view, the so called Replay was developed (see Figure 1, right). This tool is chronology replaying the chat, similar to a screen recording, but with options to select and deselect the data that is output at runtime, also showing fixations and saccades as a scanpath. Because fixations are represented by GUI elements, further information, such as fixation length and underlying AOI, can be retrieved through tooltips. Both applications, Timeline and Replay, provide the opportunity to play back the video of the user cam. Within the Replay a "Retrospective Think Aloud" can be recorded. Timeline and Replay are linked together to jump into each instance to the same position as the active tool. From the Timeline, multiple Replay instances can be started and played in sync to compare several subjects directly.

Outlook

The INKA-SUITE outlined above is a basis for a number of planned extensions. These include an enhanced fixation filter, contextualized communication, extension of simultaneous chats and the internal project called *Chat++*, which is feasible through the realtime AOI identification and could therefore support features like reading awareness, eye-tracking-based referencing and activity and context-awareness.

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The effect of computer-supported independent and interdependent collaboration on information sharing

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Abstract: As a way to look at how activity in the group influences individual cognition, this paper reviewed three literature on the effect of interdependence and independent work in computer-supported collaborative learning. Three literatures show the positive effect of interdependent collaboration on information sharing as the opposite results of previous research.

The effect of interdependent collaboration on information sharing

Previous research has identified two counterintuitive findings for collaboration work. First, individuals remember less when recalling in groups, which is a well-known effect called collaborative inhibition (Hinsz, Tindale, & Vollrath, 1997). Second, in a form of interdependent collaboration, group members mentioned more pieces of common (shared) information than unique (unshared) information, which is called hidden-profile methods (Lu et al, 2012). These two startling finding for group work clearly suggest that group work would not be as effective as working individually. Therefore, the effects of working in groups must be qualified or moderated in order for instructional designers to optimize collaborative learning for all members when they design collaborative learning.

Engleman and Hesse (2010) investigated interdependence and independent work in computer-supported collaborative learning. All the members were randomly assigned to the Interdependent and Independent conditions and required to create a collaborative concept map regarding problem-solving task using CmapTool. The Interdependent group on average spent more time on creating a fully elaborated concept map before shifting focus to solving the problem, while the Independent group spent less times on elaborating their map before focusing on solving the problem. Analysis of the content and structure of the group maps showed that the Interdependent group maps were larger and more fully elaborated relative to the Independent group maps. These findings for the Interdependent group are notable since it is the opposite pattern of previous research regarding common and unique information that group discussion tends to focus on common information than unique information (Stasser & Titus, 1985; Lu et al, 2012).

The following two studies (offline & online collaboration) were desired to measure the flow of information elicited as concept maps before (Premap), during (Group map), and after (Postmap) collaboration in order to explain or reconcile this positive pattern (Clariana et al, 2012). First investigation (called as CAS 250) was conducted in a face-to-face section of a large public University. Working alone as homework (Pre-maps), participants in the Independent condition were asked to read and map all of Chapter, while participants in the Interdependent condition were asked to read all of chapter but map only the first or last half of the chapter. After that, all members were required to create group map of the chapter (Group maps). When done, they individually completed a post assessment that consisted of creating from memory a concept map of the Chapter content (Postmaps).

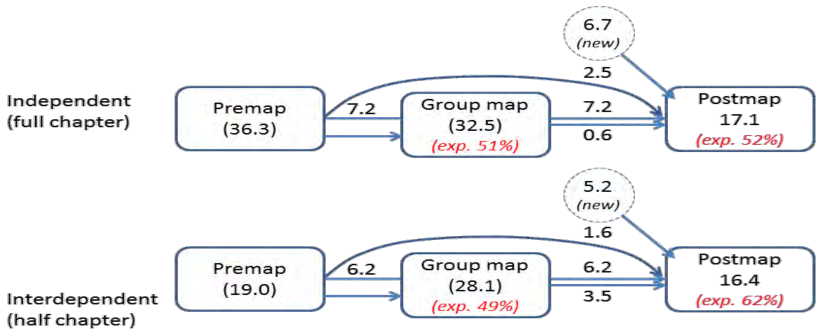

Figure 1. The average flow of Posttest concepts for each condition across Premaps, Group maps, and Postmaps.

As showed, for the Premaps, not surprisingly map sizes were on average about half as large for the Interdependent condition. This is consistent with mapping half of the chapter versus mapping the whole chapter. Group maps were approximately equivalent in terms of quality and size. Interdependent group agreement with the expert was 49% compared to 51% for the Independent group maps. Regarding Postmaps, average Postmaps for each condition were approximately equivalent in terms of size but not in terms of quality, the Interdependent agreement with the expert was 62% compares to 52% for the Independent group maps. These findings indicate that interdependent group work does lead to unique (and quality) information sharing because they must have learned the other half of the chapter that they had not studied through the group collaboration. In addition, what they learned in the group tended to be of higher quality.

Another remarkable finding is the fact that 21% (0.6 terms) of the terms in the Interdependent postmaps came exclusively from their Group maps while only 4% (3.5 terms) of the Independent postmaps came exclusively from their Group maps. This suggests that the Independent group members paid less attention to their group's map. In other word, independent Postmap was more dependent on their Premap and their own unique knowledge than on their Group map. These finding suggests that collaboration more strongly influence the learning in interdependent condition than in independent condition.

Armed with information from this investigation, a related follow-up study (called as IST 110) underway now will replicate this approach (Preamp-Groupmap-Postmap) online and include video analysis of the group collaboration in order to describe the collaborative group process. In this study, all members were individually required to complete Post Lesson Quiz that consists of 20 fact-related items in order to more clearly identify the effect of information sharing in collaboration. This investigation showed the effect of interdependent group work on information sharing. Bellow figure 2 shows the result.

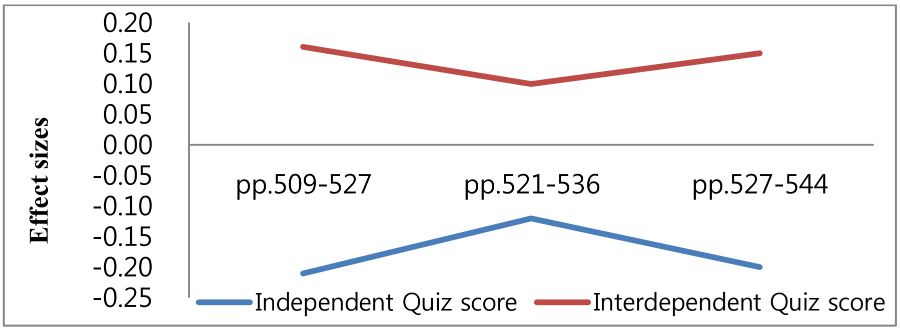

Figure 2. Quiz score of both interdependent and independent members.

Given the results from three investigations, our current conclusion is that interdependent collaboration work (1) may be an effective way to share unique information, and (2) collaboration strongly influences the learning in interdependent collaboration condition than in independent collaboration.

Next step

The latter two investigations (CAS 250 & IST 110) are our beginning step to understand the flow of information pieces (as structural knowledge) in group collaboration as a way to look at how activity in the group influences individual cognition. As a next step, IST 110 study will further investigate the relational and associational knowledge beyond the extent of knowledge in computer-supported collaborative problem-solving task. The main premise underlying this research is that different collaboration strategies, whether independent or interdependent, may influence different knowledge structure, which in turn engenders different performance. At this time, our expectation is that independent collaboration strategy may be effective way for knowledge convergence, while interdependent collaboration strategy may be effective for information sharing as proven by the research reviewed in this article.

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Transforming the Learning Difficulties to Teaching Moments

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Abstract: This study aims to uncover what knowledge is brought forth in an embodied modeling mediated activity by prospective teachers (PT) and how these learning experiences are connected with their teaching practices in an informal learning context. We employ qualitative methodologies to investigate these questions. Finding shows that based upon learning-through-modeling experiences, PTs effectively transformed their learning difficulties to valuable teaching moments for their workshop participants. Implications of this study are discussed.

Introduction

Previous studies have shown that despite of affordances of modeling-based learning and teaching, most teachers experience difficulties (Kenyon, Davis & Hug, 2011). Through adopting a design-based research, we have co-designed an 'Embodied Modeling Mediated Activity' (EMMA) with an experienced teacher in informal learning contexts to offer observation-based authentic experiences and related follow-up multimodal modeling activities for prospective teachers (PTs) in informal learning contexts. We hope to not only provide PTs with modeling-based learning experiences but also offer them opportunities to co-design and conduct EMMA activities. The study specifically looks into what knowledge is brought forth in an embodied modeling mediated activity by prospective teachers (PT) and how these learning experiences are connected with their teaching practices in an informal astronomy workshop concerning the concept of size and distance.

Theoretical Background

The concept of size and distance has been under-researched and even under-taught (Lelliott & Rollnick, 2009). Students' difficulty lies with their lack of life experiences related to vast distance and misinterpretation of their observation (Bakas & Mikropoulus, 2003). Modeling-based learning has been proved to improve students' conceptual understanding (Kenyon, Davis & Hug, 2011). Creating opportunities for students to teach can promote their content knowledge and pedagogical content knowledge as well as maximizing their potential (Cortese, 2005). Our project has endeavored to provide the workshop participants with teaching experiences based upon their learning experience in EMMA workshops.

Methods

Five youth volunteers as PTs (aged 17-18) were engaged in this qualitative study. The commitment of conducting an astronomy workshop through participating in the EMMA I and II workshops motivated them to equip themselves with astronomy content and pedagogical knowledge. Their learning activities were co-designed by the research team and one expert physics teacher (HJ, pseudonym) with strong interests and rich content knowledge in Astronomy. EMMA III was specifically designed toward authentic, embodied experiences of sky observation and multimodal modeling activities situated in an overseas field trip. Finally, EMMA IV was designed for PTs to conduct an astronomy workshop in a community center for facilitating 30 secondary school students. For deeper understanding of PT's learning and teaching experiences, multiple data sources were collected such as videotaping of the workshops, artifacts, surveys concerning PTs' perceptions of the nature of science and metamodeling, post-interview, and field notes. Data were analyzed using constant comparison methods (Strauss & Corbin, 1990). Three researchers went through an iterative process of the following steps using NVivo. First, modeling processes were identified in the EMMA III and IV workshops. Secondly, episodes were defined based on astronomy related topics in a group discussion. Thirdly, micro-level analysis was conducted to understand how PTs' learning experiences were connected with their teaching practices.

Findings

During the EMMA III workshop, the mentor, HJ, intentionally put forward a geocentric model argument and asked PTs to construct their models to prove that his geocentric model of planets was wrong. While constructing their planet models, PTs faced two main difficulties and their actual teaching indicated their abilities to transform their own learning difficulties to teaching moments, as elaborated in the following findings.

Making both Distance and Size on the Same Scale

In EMMA III, HJ purposefully encouraged PTs to combine both the distance and size of the planets on the same scale for constructing the model. PTs' initial model was poorly scaled (Figure 1). After receiving feedbacks from HJ, they started to appreciate the vast celestial scales and applied the strategy of eliminating oversize or distant objects to make their scaling model feasible for construction (Figure 2).

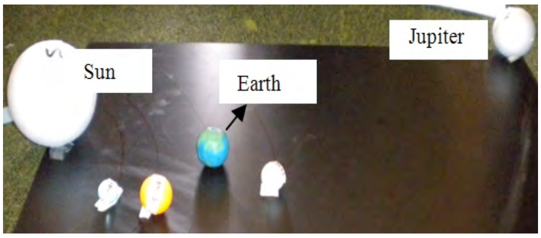

Figure 1. PT's initial model in EMMA III.

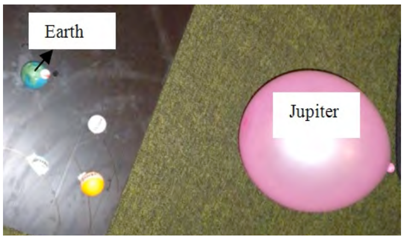

Figure 2. PT's revised model in EMMA III

This allowed them to pay more attention on the accuracy of distance and size, which in turn decided to create a guided modeling activity for their own students in which the topics of 'size' and 'distance' were separately introduced rather than combining them in a same scale. PTs guided the workshop participants by questioning about the accuracy of their models. Hence, the workshop participants improved the accuracy in scaling (Figure 4) compared to their initial model of the planets arranged at a same distance from each other (Figure 3).

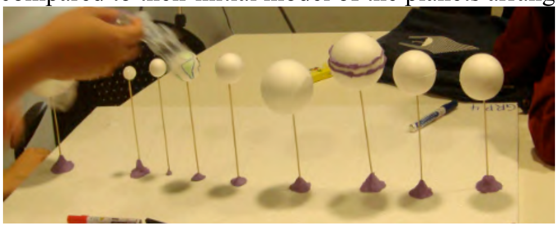

Figure 3. Participants' initial poorly-scaled model

Figure 4. Participants' revised better-scaled model

Using models to explain observations from different perspectives

To debate with HJ's argument of the geocentric model, PTs needed to reconstruct their initial model (Figure 5) that simply represented the alignment of planets that appeared in the sky photo. HJ advised PTs to use a red pin to represent their position on the Earth so as to help them perceive 3D spatial perspectives. PTs eventually revised their model that was able to explain why the Moon appeared higher and bigger than Jupiter (Figure 6). The revised model showed they have transformed the 2D representation with 3D spatial reasoning.

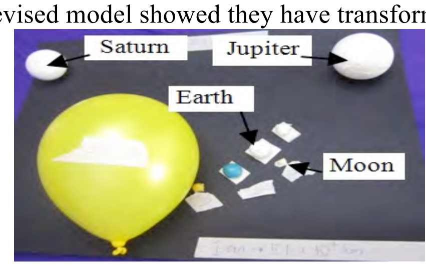

Figure 5. Planetary alignment model before revision

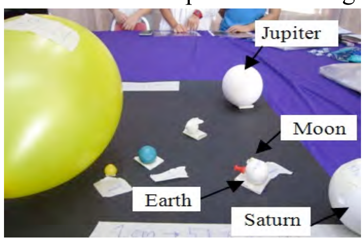

Figure 6. Planetary alignment model after revision

Based on their own hands-on modeling learning experiences, PTs effectively employed a real-time simulated observation picture to generate an argument and requested the workshop participants to argue each other using their own models. Although most workshop participants tended to pay more attention on displaying factual information without making connections with their models explicitly, it is worth mentioning that PTs noticed the explanatory power of models and explicitly asked the workshop participants not only to use the model to explain their reasoning but also to address the limitation of their own models.

Discussion and Implication

Modeling of planets required PTs to understand the complex interrelationships among distances, sizes and positions of celestial objects, as well as viewing them in different perspectives. Hence, this study demonstrates that observation integration in multimodal modeling affords PTs to overcome their learning difficulties and develop spatial reasoning. As indicated above, PTs designed activities for engaging participants in experiencing, collaborating and arguing through modeling rather than direct teaching. This implies the important role of teachers' authentic learning experiences.

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Supporting Student Choice and Collaborative Decision-Making During Science Inquiry Investigations

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Abstract: This study investigates the impact of providing students with opportunities for collaborative choice-making during inquiry learning with *Investigating Seasons*, an online curriculum module. Two versions of *Seasons* (*no-choice* and *choice*) was implemented with ten classes of high school students (N = 207). Study findings indicate that students in the *choice* condition demonstrated greater gains in their conceptual understanding of seasons as well as a higher increase in normative written explanations compared to the *no-choice* students.

Introduction and Rationale

Despite research documenting the tremendous benefits of introducing more authentic forms of inquiry into the classroom (e.g., White & Frederiksen, 1998), most science teachers do not have the adequate classroom time or resources to involve their students in independent inquiry investigations and are forced to turn instead to the use of linear step-by-step "cookbook labs" that bear little resemblance to authentic inquiry practices.

The *Seasons* unit aims to strike a balance between rigorously structured "cookbook" inquiry (lacking in rich learning outcomes but easier to implement) and inquiry that is more authentic and open-ended (highly challenging to implement but with potentially more powerful learning outcomes) by incorporating student choice. Allowing students to choose and decide upon their own inquiry paths "accommodates and values the diversity" of learners; "by allowing for multiple entry points and multiple paths, all students ultimately come into proximity to core learning goals, with richer and deeper learning experiences" (Murata, 2012, p. 20). In addition, in making their choices, student pairs are given the opportunity to collaboratively discuss and compare their developing ideas together.

This study explores the effect of providing choice during inquiry and considers research questions such as: How does providing students with the option to choose their own path of inquiry investigations affect their learning and conceptual understanding of seasons? Does instruction that scaffolds students' choice-making result in improved learning outcomes for students? If so, why is providing choice effective for learning?

Theoretical Framework

This research work adopts a constructivist perspective towards learning, in which the pre-existing ideas that learners have are viewed as productive starting points for instruction to leverage towards more scientifically valid and integrated understandings of challenging science ideas and concepts (Smith, diSessa, & Roschelle, 1993). For example, while changing distance between the Earth and the Sun is the primary misconception about seasons cited in the research literature, it is not the only strongly held misconception. A survey that this author administered to 9th grade earth science students (N = 102) revealed that nearly just as many students cite Earth's orientation towards or away from the Sun as the primary cause of seasons (N = 30; 29%) as those who mention the changing Sun-Earth distance (N = 32; 31%), suggesting that inquiry instruction on the seasons should be flexible and adaptable enough to acknowledge and address the variety of starting prior ideas across all students.

Methods

Investigating Seasons, a ten-hour WISE (Web-based Inquiry Science Environment) curriculum module, incorporates interactive dynamic visualizations and instructional scaffolding to support students in conducting experiments, collecting data, and integrating their diverse ideas for explaining seasonal temperature changes. The unit contains five inquiry investigations covering key concepts central to understanding the phenomenon of seasonal temperature changes.

For this study, two versions of *Seasons* (*no-choice* and *choice*) was used with ten classes of ninth-grade earth science students (N = 207) at a socially and economically diverse high school in California. Students worked through the unit in pairs. The *no-choice* version of *Seasons* presented students with the five inquiry investigations in a preset order. The *choice* version of the curriculum, in contrast, allowed student pairs to decide upon and choose their next investigation together. In particular, students in the *choice* condition were encouraged to discuss their ideas with one another in order to come to an agreement as to which of the five investigations to complete next (see Figure 1).

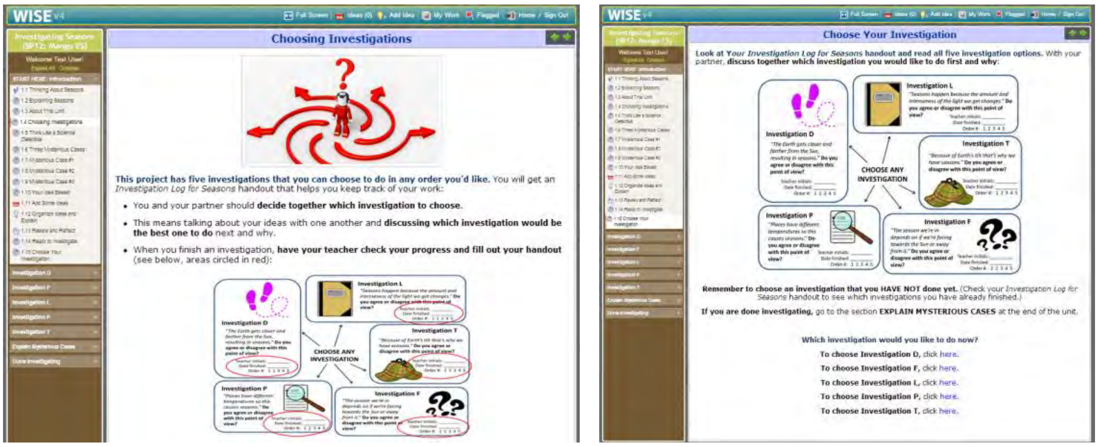

Figure 1. Student pairs were encouraged to discuss and decide together which investigation to choose next.

Results

Students were administered individual pre- and post-unit tests. Explanations were scored on a scale from 0-4 using a knowledge integration (KI) rubric which rewards the number of valid scientific connections present in the explanation (Linn, Lee, Tinker, Husic, & Chiu, 2006). Analysis of pre- and post-test explanations revealed higher levels of knowledge integration for students in the *choice* condition. Students in the *choice* condition made moderate, significant pre- to post-test gains (M = 1.49, SD = 0.79 (pre); M = 1.91, SD = 0.92 (post); $t(109) = 3.70$, $p < 0.001$, $d = 0.49$) while students in the *no-choice* condition demonstrated small pre- to post-test gains (M = 1.46, SD = 0.70 (pre); M = 1.69, SD = 0.83 (post); $t(76) = 1.84$, $p = 0.07$, $d = 0.30$). Furthermore, students in the *choice* condition demonstrated a greater percentage in both increase of normative explanations (from 24% to 41%) and decrease of non-normative explanations (63% to 50%) compared to their study counterparts; for the *no-choice* students, the percentage of both normative explanations (from 29% to 32%) and non-normative explanations (63% to 58%) remained roughly the same pre- and post-unit. One possible explanation for these findings is that since *choice* students were encouraged to discuss their ideas together before deciding on their next investigation, they may have more actively engaged in comparing and reflecting upon their developing ideas about seasons. Further in-depth analyses using other collected data sources (e.g., videotaped data of student pairs working together) may help to further inform and contextualize these findings.

Significance of Study

Research indicates that the benefits of successfully engaging students in more authentic and open-ended forms of inquiry are numerous. Providing students with the opportunity to make choices during their own inquiry learning can help to support diverse and unique paths of learning for different students while also encouraging the collaborative exchange of ideas between students during choice-making. Hopefully the findings from this study will in turn spark rich and productive discussions among session participants about how to design science instruction that can effectively promote student choice and collaborative discussion during inquiry and learning.

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Social Design in Digital Simulations: Effects of Single versus Multi-Player Simulations on Efficacy Beliefs and Transfer

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Abstract: Drawing on social cognitive theory, the study tested the effects of single-player versus multi-player simulations on self-efficacy and transfer of learning by psychometrically cumulating 25 years of research with a total sample size of N=2,274. Preliminary results indicate no significant difference between conditions. Implications for computer-based instructional design and directions for future research are discussed.

Introduction

Digital simulations can be defined as technology-based programs that contain a model of a system or a process (De Jong & Van Joolingen, 1998). Digital simulations are becoming increasingly popular in adult education for learning complex cognitive skills, largely because the similarity between natural phenomena and their simulated representations promotes transfer of learning (Mayer et al., 2011). Some authors argue that this transfer is further promoted through high levels of self-efficacy (Bandura, 2012; Gegenfurtner et al., 2013). However, other authors argue that simulations, regardless if digital or face to face, need to be carefully designed before they can be expected to promote self-efficacy and transfer (Garris et al., 2002; Knogler & Lewalter, in press). Based on this discussion, it is yet unclear how social design contributes to regulating learners' levels of efficacy beliefs and subsequent transfer of learning (Pineda et al., 2011).

The present study intended to contribute to this discussion by meta-analyzing the available evidence from the past 25 years. The aim was to cumulate previous research in order to correct the size of true score population correlations between transfer and efficacy beliefs. A focus was on the contextual variation between studies that offered different shades of computer-supported individual learning (CSIL) and collaborative learning (CSCL), indicated by the number of players. Single-player simulations indicated individual learning (as in Bell et al., 2008). Multi-player simulations indicated collaborative learning (as in Orvis et al., 2009).

Based on social cognitive theory (Bandura, 2012), we assumed that learners in multi-player simulations, when compared with learners in single-player simulations, had higher population correlation estimates between self-efficacy and transfer of learning, largely because multi-player simulations offer higher degrees of social exchange and co-regulation processes while engaging with the digital simulation tasks (Bandura, 2012; Garris, 2002; Gegenfurtner et al., 2013; Tompson & Dass, 2002).

Method

Literature Searches and Inclusion Criteria

We performed a systematic review of the literature. To be included in the database, a study had to report an effect size r or other effect sizes that could be converted to r (b coefficient; Cohen's d; F, t, or Z statistics). Because the focus of inquiry was on task self-efficacy as an individual capacity (Bandura, 2012), the database included studies that reported data on individuals. Studies reporting group-level data were omitted. We excluded studies on computer self-efficacy, as the focus was on task-related self-efficacy. Studies on non-adult samples were also excluded. We included studies that assessed transfer with objective performance measures while we excluded studies that used self-ratings of transfer. Studies published in peer-reviewed journals over the last 25 years, from January 1986 to December 2011, were located in several ways. First, we searched the PsycINFO, ERIC, and Web of Science databases using relevant keywords. Second, we cross-referenced the retrieved articles as well as recent reviews and special issues on self-efficacy, transfer of learning, and simulation-based training (Garris et al., 2002; Gegenfurtner, 2011; Segers & Gegenfurtner, 2013). A total of 15 journal articles that contributed at least one effect size to the meta-analysis met all inclusion criteria.

Coding of Variables and Computation and Analysis of Effect Sizes

Three independent coders coded a randomly selected subset, 13.33% of the studies from the final sample. Intercoder reliability was generally high (Cohen's κ = .82). Uncertainty in codability was resolved through collaborative discussions. Each study was coded for psychometric information and the social design element (single-player vs. multi-player). Analysis occurred in two stages. First, a primary meta-analysis aimed to estimate the true score population correlation ρ of the relationship between self-efficacy and transfer of learning. Distributions of Pearson's r were corrected for sampling error and error of measurement using the compiled Cronbach's α reliability estimates (ρ). Second, a meta-analytic moderator analysis aimed to identify moderator effects. Theory-driven sub-group analyses were used to estimate the effects of single-player versus multi-player simulations on the population correlation estimate between self-efficacy and transfer of learning.

Results and Their Educational Significance

The 15 studies that were included in the meta-analysis had a sample size of 2,274 learners with a mean age of 21.40 (*SD* = 2.84). 49.24% of the learners were female (*SD* = 21.88). Participants were students in higher education in 13 studies and military cadets in two studies. The true score population correlation ρ corrected for both sampling error and error of measurement was .38 (*SD* = .02; 80% CV = .35; .41). Preliminary results of the meta-analytic moderator estimation suggest higher estimates for single-player compared with multi-player simulations. However, although results indicate higher estimates in single-player simulations, the differences between conditions are relatively small, and non-significant, $p > .05$, as the 80% credibility intervals overlap.

Given that digital simulations become increasingly popular environments for teaching complex cognitive skills (De Jong & Van Joolingen, 1998; Mayer et al., 2011; Siewiorek et al., in press; Tompson & Dass, 2002), the aim of the present study was to cumulate previous research in order to correct the size of the true score population correlations between transfer and self-efficacy. In addition, the aim was to estimate the moderating effects of a social design element: single-player versus multi-player simulations. Implications for theory development include a first step toward generating a design-based model of learner efficacy in simulation-based e-learning environments (Pineda et al., 2011). Future research can extend the findings reported here to see whether the present results on self-efficacy can generalize to other motivational dimensions (Garris et al., 2002; Gegenfurtner, in press; Knogler & Lewalter, in press), vary over different digital infrastructures, and are stable across different social design elements. Another direction for future research includes a focus on different samples, such as non-adult populations in K12-education (Knogler & Lewalter, in press).

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Treasure-HIT: Supporting Outdoor Collaborative Activities with Mobile Treasure Hunt Games

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Abstract: Treasure-HIT is an environment that aims to support the design and enactment of location based games conducted via mobile phones. The system allows teachers to define a set of locations (using Google Maps and Google Street APIs), to attach clues that direct the players to the locations and to conduct specific activities at each location. The system will be tested with teachers designing outdoor learning activities for the subject My Village as part of the national curriculum for elementary schools. In the poster session we shall demonstrate the functionalities and potential of the system for designing outdoor collaborative activities, present examples of games designed by teachers and discuss insights gained from the pilot study with teachers and students.

Introduction

Recent advancements in mobile technology provide new opportunities to design innovative pedagogical activities that expand beyond the boundaries of the traditional classroom (Sébastien & Audrey, 2011). These activities could be enacted across learning planes and include sequenced interactions performed across various physical spaces involving different group size of participants (Giemza, 2012; Vavoula et al., 2009). Technological support could be enabled across these activity planes providing students with a meaningful and seamless learning experience (Chan et al., 2006).

One of the approaches of combining the outdoor space in learning is by treasure hunt type games. In such games, participants are challenged to identify specific sites according to clues and to reach these sites. Educational treasure hunt games represent a cross plane pedagogical approach that introduces students with location based learning experiences (Kukulska-Hulme, 2008). This approach was traditionally enacted without any technological support (Eliot, 1926). Recent developments of mobile technologies offer new opportunities to provide direct support for such games by: tracking participants' locations in real time, presenting the game clues in various multimedia formats, enactment of pre-planned interactive activities related to the sites, collecting and sharing digital information contributed by the participants, communication between participants and with the game's instructor and controlling the activity by the game manager. This potential was recently exploited for the design of educational treasure hunt type games, supported by mobile technology (Spikol & Milrad, 2008; Hooper & Rettberg, 2011; Tol, 2008).

We present an attempt to design and develop a pedagogical treasure hunt environment enabling teachers to design cross planes activities taking advantage of the mobile devices commonly available to students.

Design a Game with Treasure-HIT

Treasure-HIT is an authoring system aimed to enable teachers to design and enact outdoor activities that are supported by GPS enabled mobile devices. These activities may resemble the classic treasure hunt game presented as a competition between teams or as a collaborative effort of teams to identify and reach a final destination.

The system includes two main components: an authoring web environment used by teachers to design activities and the player's mobile application environment used by the participants (students) during the game enactment.

The author web interface provides the ability to define a set of landmarks (stations) by using embedded Google Maps and Google Street View API features and to present clues leading the players to the station. The clues can be formulated using any type of media: text, image, video, website and sound. In addition, the teacher can attach specific tasks to be performed by the players at each station, as a condition for advancing in the game. The tasks may include quizzes of various kinds and data collection for further collaborative use. Figure 1 presents an example of the station authoring interface. In this example, students will be offered with two clues: some textual information about the station and a visual hint. When arriving at the station the players will be presented with two quiz questions and a task to be performed on site, aimed to collect and share information with other participants.

The player application supports most popular mobile operating systems and has to be installed in the personal device prior to its use. Players access a specific game by using unique code provided by the teacher.

Initial instructions will be presented and clue/s leading to the first station. The player checks if he arrived at the desired location by activating the GPS tracking (Fig. 1). If detected within the tolerance range from the defined location the game continues according to the designed scenario: tasks attached to this station are presented, and after their completion the system will provide clues to the next station.

The teacher can define the game scenario by setting the order of presentation of the stations to the groups. The order can be identical for all identical of different. For instance, if the game is played across ten stations, the route of each team may include only four different stations, while the end station is identical to all. The author environment allows teachers to share games and use them as pedagogical resources. Teachers can view games created by other authors and adopt each other's games.

Figure 1. The station authoring interface and an example of a mobile display during the game.

The first version of Treasure-HIT will be tested with teachers and students during the current academic year. The system will support outdoor activities designed for the subject "My Village", a topic included in the national curriculum for elementary schools. Teachers will design games adapted to their villages, aiming to familiarize students with important sites of interest in their close vicinity.

In the poster session we shall demonstrate the functionalities and potential of the system for designing outdoor collaborative activities, present examples of games designed by teachers and discuss insights gained from the pilot study with teachers and students.

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Evaluating Virtual Collaboration Over Time – A Pilot Field Study

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Abstract: This pilot field study investigated the evaluation of virtual collaboration and of support methods over time asking 32 undergraduates studying pedagogy with a survey questionnaire at three points of time. Results indicate a specific evaluation pattern showing that at all three points of time, taking responsibility was evaluated lowest. Furthermore, correlation analyses showed that the support of designing group work was connected significantly with taking responsibility indicating a positive influence for supporting virtual collaboration.

Introduction and Theoretical Background

In CSCL research, there is insufficient discussion on learners' subjective perception of the collaboration process and of support methods. Furthermore, the question is how learner's evaluation on these two dimensions changes over a period of time. Another issue is to look at the correlations between virtual collaboration and support methods. Therefore, this paper deals with these three issues.

Looking at the collaboration process first, main dimensions include the task and the social level of collaboration. The task level involves goal orientation and task completion, the social level group cohesion and taking responsibility (Kauffeld, 2001). The main issue is to see how these dimensions develop in evaluation over time.

Second, as virtual collaboration needs support we included two support methods, namely the design of group work (the assignment of roles and group rules), and providing feedback on the performance and worked examples to see, how these means are effective for online collaboration.

Third, looking at the theoretical and empirical background, there is no indication on how group members themselves evaluate their collaboration over time and whether there are changes regarding group processes. Furthermore, the development of support on collaboration over a period of time has not yet been investigated. Specifically, the question is whether support is more effective at the beginning than at the end.

Research Questions

Based on the theoretical background, we investigated three research questions, namely

1. How do students evaluate virtual collaboration and support methods?
2. To what extent do evaluations differ over time?
3. To what extent do the design of group work and feedback correlate with virtual collaboration over time in terms of goal orientation, task completion, cohesion, and taking responsibility?

Method

Object of Investigation

We investigated the seminar on "Attachment Theory". Didactically, the seminar followed a problem-based approach asking learners to apply collaboratively their theoretical knowledge to authentic problems from multiple perspectives and contexts in the field. To support online collaboration, we included two methods: designing the group work (assignment of roles, and definition of group rules), and providing learners with feedback (feedback on the individual group's solution, and worked examples).

Sample and Design of the Study

Thirty-two undergraduate students majoring in pedagogy took part in the survey study. They were divided randomly into eight groups with four members. All students filled in an online questionnaire regarding support methods and the virtual online collaboration at three points of measurement beginning five weeks after the start of the seminar and continuing two more times every four weeks.

Data Sources

We developed a questionnaire focusing on online collaboration and support methods. To evaluate collaboration, we used the questionnaire for teamwork by Kauffeld (2001) with four dimensions, namely at the task level, goal orientation and task completion, and at the social level, group cohesion and taking responsibility. We used a six-point Likert scale ranging from 1 ("do not agree") to 6 ("totally agree"). To measure support methods, we used again a six-point-Likert scale from 1 ("not effective at all") to 6 ("very effective") asking how effective certain support was for group work.

Data Analyses

In a first step, we calculated the descriptive statistics of the relevant dimensions at the three different points in time. Second, we looked at differences between the single dimensions using t-tests for paired samples. In a third step, we calculated the differences of the single dimensions between the three points of time using t-tests for paired samples. Fourth, we correlated the dimensions on collaboration with the dimensions of support methods using a Pearson's one-way correlation analysis. The level of significance was .05.

Results

Research Question 1

Students evaluated virtual collaboration and support methods on a very high level with low standard deviation at all three time intervals. T-test analyses showed significant differences at all three points of time, showing that taking responsibility was evaluated lowest, followed by goal orientation. Regarding support methods there was only one significant difference at the first point of measurement ($t(31)=2.57$; $p<.05$).

Research Question 2

Looking at the development of the virtual collaboration, the evaluation remains homogenous. T-Test showed one significant difference between the first and second point of time, namely between the evaluation of task completion ($t(29)=2.15$; $p<.05$). Looking at the support methods, there was also one difference between the first and second point of time in the evaluation of providing feedback ($t(29)=-2.97$; $p<.01$).

Research Question 3

Results show that group design positively correlates with all four dimensions of collaboration at the first and second point of time, and with the two social dimensions of group cohesion and taking responsibility at the third point of time. These correlations are significant. The correlation is on a medium to high level with the highest scores at the second point of measurement. Providing feedback significantly correlates only once with taking responsibility at the first point of measurement. There were no further correlations between support methods and the collaboration process.

Discussion

There are three main results: First, the evaluation shows a specific pattern. Looking at collaboration, task completion was evaluated highest, followed by group cohesion, goal orientation, ant taking responsibility indicating that possibly not all group members feel in the same way responsible to fulfill their joint group solution, eventually due to the missing social presence in virtual learning environments. Nevertheless, the main purpose of the virtual seminar to solve tasks together was very much internalized by the students. Regarding support methods, the design of group work was evaluated higher than providing feedback, which also stayed stable over time. A reason for this may be that group design affects the collaboration process itself, while the feedback was given after the respective task completion which may be of interest for the next task solution, but not for the direct collaboration process. Second, regarding the development of the virtual collaboration, the evaluation of group processes and of support methods stayed almost stable over time. Third, group design correlates almost always with all dimensions of the collaboration. The design of group work influenced directly the group processes. Looking at the extent of the correlation numbers, they are highest at the second point of measurement. This may be explained with the stages in group process by Tuckman (1965). Possibly, in the middle of the semester, the groups were in the storming and norming stage, in which concrete rules how to collaborate and a moderator who leads the group process, is of great relevance for the learners. Because of this, support and group processes were highly related to each other.

Educational Significance

Results indicate that according to the subjective evaluation data, there is a positive relation between support methods and group interaction which justifies the necessity of support for computer learning even based on this subjective evaluation data. Especially problematic social phenomena are strongly related to the given instructions of group design. Therefore, support that affects the collaboration process is an essential part in virtual collaboration.

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iSocial: Collaborative Distance Education for Special Needs

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Abstract: iSocial is an innovative 3D Collaborative Virtual Learning Environment (3D CVLE) to provide access to educational programming for students with special needs who live in small and rural school districts. The research reported here is part of a design research process for developing virtual learning systems to improve learning for students with special needs who live in rural/small districts. A field test of iSocial with 11 students shows promise, but also identifies challenges for distance education with 3D collaborative virtual learning.

Introduction

Distance Education (DE) is a growing phenomenon in small and rural schools (nearly 10 million students attend rural schools) as a means for meeting student needs for courses such as foreign languages and advanced placement. DE also has the potential to bring specialized curriculum and teaching to students with special needs. Unfortunately typical DE is limited in how it provides support for affective and social learning (Rice, 2006) which is often critical to addressing students with special needs. A form of DE that can be highly engaging and social is 3-dimensional collaborative virtual learning environments (3D CVLEs). With a grant from the Institute of Education Sciences, the iSocial project is developing a 3D CVLE for building social competence for youth with a diagnosis of Autism Spectrum Disorder (ASD) who do not have ready access to such interventions in their local schools and communities. iSocial is a translation of a curriculum (Social-Competence Intervention for Adolescents, SCI-A) delivered in face-to-face sessions with demonstrated efficacy for the target students into a 3D CVLE for delivery over the Internet. In the process of undertaking this translation our team has designed solutions for: (1) assuring fidelity between the 3D CVLE experience and the cognitive and behavioral processes and objectives of the face-to-face curriculum implementation, (2) encouraging, supporting and sustaining appropriate social behavior and interaction in the virtual world, especially considering that our target students have social limitations, and (3) building social competence on the part of the students in ways that will improve their social functioning in school and in their community.

3D CVLE and youth with ASD

In 3D CVLEs students represented by an avatar enter a 3D scene with objects and other avatars using a networked computer. Collaboration is supported by students being able to see each other's (and the teacher's) avatars, manipulate objects in the VLE, interact through movement and gesture via their avatars, and use voice to speak to each other. Through these mechanisms, the medium can support DE that brings students together for peer interaction, experiential learning through collaborative effort, and guidance by an expert teacher.

The iSocial VLE (Laffey et al., 2009) delivers the SCI-A curriculum over the Internet to allow youth from small and rural schools to come together with an expert teacher in a DE course. The students take 34 lessons of 45 minutes each with lessons scheduled for 2 to 3 times per week. The lessons are packaged in 5 curriculum units: facial expression, sharing ideas, turn taking, feelings and emotions, and problem solving and delivered in a series of 3D virtual worlds. Each unit is a sequence of collaborative activities to learn about and practice new social competencies. The units culminate in a naturalistic practice activity that encourages and requires the students to work together and use their new competencies to accomplish a task or solve a problem.

Methods

Three school districts worked with the iSocial team to identify qualified students, schedule an appropriate time for instruction, provide on-site personnel for supervision and technology support, and resolve technology issues such as providing sufficiently powerful computer stations and network bandwidth as well as providing access through school firewalls. Eleven students, who met the target qualifications, were enrolled in one of 3 courses (n = 4, 4 & 3). A standardized measure of social competency for youth with ASD, the *Social Responsiveness Scales* (SRS; Constantino & Gruber, 2005), was completed 2 weeks prior to instruction and 2 weeks after instruction.

Findings

The **outcomes** data for the SRS instrument are presented in Table 1 with improvement indicated by score decreases from pre to post assessment. Keeping in mind that the total sample is small for statistical comparisons, and that caution must be applied to any conclusions drawn, we find interesting variety in the distribution of outcomes across the school sites. Schools 1 and 2 show substantial improvements in parent ratings, especially when compared to results for school 3. Schools 1 and 3 show improved teacher ratings especially when compared to school 2. The results show that social competence can manifest itself differently at school or at home. For each school, and in turn each individual, the impact of iSocial may manifest itself differently. For example one student at school 2 improved dramatically based on the parent rating but was rated more negatively by the teacher from pre to post. We find these outcomes data to be promising in that they indicate that iSocial is generally associated with improved social competence, and in some cases substantially improved outcomes. However, the data also suggest that there is more to be understood about whether it is possible and under what conditions we could expect consistently positive results.

Table 1. iSocial Field Test pre and post measures for learning outcomes.

Instrument	School 1 - N=4		School 2 - N=3		School 3 - N=4	
	Pre	Post	Pre	Post	Pre	Post
Parent SRS Total (a)	114.50	81.25	95.00	55.00	94.00	90.50
Teacher SRS Total (a)	90.50	62.25	77.67	76.33	106.50	95.50

Discussion

The successful implementation of iSocial (11 students completed the iSocial course via DE) and student gains on measures of social competence show significant promise for using 3D VLE as DE for students in small and rural communities. Whether students would be social and whether the online teacher could manage social behavior in the VLE were substantial challenges for the project. Through a design research process we learned and subsequently implemented design features for the VLE which support the forms of social practices needed for implementing the curriculum (Schmidt, Laffey & Stichter, 2011). While results of our pilot study are promising we have also identified substantial challenges to implementing an innovative technology-based program in small and rural schools. For example technology failures, some minor such as brief audio interruptions and some major including system crashes, were frequently encountered. Each student averaged 2.3 incidences per lesson (Laffey, Stichter and Galyen, 2013). In general the incidences were fairly quickly addressed and students were able to complete lessons, but teaching and learning time was reduced, some students became frustrated with the system implementation, and vigilant attention to support was needed (approximately 1/3 of TURIs required some form of technical assistance). Some of the technology issues can be attributed to the pilot nature of our software system, but others stem from the somewhat fragile and idiosyncratic natures of technology infrastructures in schools. Each school in the pilot had a different technology profile and a different level and set of technology issues Applications like iSocial require high and consistently performing networks, graphics and processing capabilities. The potential for 3D CVLE to meet the special needs of students is impeded by the limits of and variability across technology infrastructures of schools.

More students need to participate in iSocial and be tested for outcomes before claims can be made about the significance of outcomes. However, analysis of achievement on the standardized measure of social competence shows the promise of addressing special needs through 3D CVLE using DE. The success of 3D CVLE, as resilient learning systems for DE that resonate with the social, affective and cognitive needs of the teacher and learners, however, will ultimately be determined by how well the various aspects of curriculum translation, technology innovation and school infrastructure can be integrated for meeting student needs.

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Exploring the effect of online collaborative learning on students' scientific understanding

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Abstract: This study explored the impact of online collaborative learning on students' understanding of the nature of scientific theory. The participants consist of 52 college students who attended a course titled "Introduction to Nature Science". Data sources came from (1) a pre-post survey that assesses students' understanding of the nature of scientific theory, and (2) students' online interactions. Findings indicate that after engaging in online collaborative learning for a semester, students demonstrated a more informed understanding of the nature of scientific theory.

Introduction

We are entering into a technology-rich and knowledge-based age, in which education is expected to help learners develop more creative and adaptive skills. Gloor (2006) mentioned that many creative endeavors are not personal achievements, but the result of collaborative knowledge construction. Against such a background, how teachers can help foster students' capacity for more collaborative learning becomes an important learning challenge. To this end, in this study, we employ "knowledge building pedagogy" as an instructional approach (Scardamalia & Bereiter, 2006), to transform students' learning experiences in a course that aimed to improve students' understanding of nature of scientific theory.

Literature review

Nature of science

Studies have pointed out that helping students enhance their understanding of the nature of scientific theory is important. In general, there are two views of nature of scientific theory. Table 1 shows some different, selected features between the traditional and modern views of nature of scientific theory.

Table 1. Two views of nature of scientific theory.

	Traditional objectivist view	Modern constructivist-interpretivist view
Nature of scientific theory	1. Theories are based on observation. 2. New theories can improve old theories, because observations can improve and increase over time. 3. An entire theory is falsified if subject to a single contradictory fact. 4. A theory is a hypothesis that has been proven to be correct. 5. Old theories are of no use to scientists.	1. Observations are theory laden. 2. Theories are invented by scientists. 3. Theories are used to describe, explain, and predict scientific phenomena. 4. Theories are conformed by certain paradigms. 5. Observations are influenced by social factors.

Revised from Palmquist and Finley (1997)

Knowledge building

In this research, we use knowledge building pedagogy instead of textbook-based instruction to facilitate students to engage in reasoning about, understanding of, and improving scientific theories. Knowledge building is very different from traditional knowledge-telling pedagogy. Knowledge building practice focuses on improving ideas and collective knowledge in a community, capitalizing on collective responsibility for sustained knowledge construction, and for fostering self-directed learning. Moreover, knowledge building fosters a collaborative learning environment for students to freely discuss scientific theories. This is to help foster their abilities of collective problem-solving and knowledge construction

Method

Participants were 52 students who attended a course titled "Introduction to Nature Science". The course lasted for one semester (18 weeks). Instructional design was based on knowledge building pedagogy, with Knowledge Forum™ (KF) being used to complement student work with ideas and knowledge. All students' ideas and discussion were recorded in KF. Data mainly came from (1) a pre-post survey that assesses students' understanding of the nature of scientific theory, and (2) students' online interactions. The questionnaire contains five open-ended questions as follows: (1) What is a scientific theory? (2) Is there a "better" or "worse" scientific theory? Why? (3) How does a scientific theory form? (4) Is a scientific theory invented or discovered? Why? (5) Why do we need science theory? The survey data were analyzed based on a coding scheme emerged during the coding process (see Table 2). Pair-sample t-test was performed to examine whether there were any significant differences between the pre- and post-test. As this was just a preliminary analysis, only analysis of pre-post survey was reported.

Result

Table 2 shows the overall results. It was found that after engaging in collaborative learning and knowledge building for a semester, the participating students' understanding of nature of scientific theory significantly changed in a more constructivist sense from pre-test to post-test (t=-5.08, p<.01). For example, there was a significant increase in understanding the origin of scientific theory from a more subjective, intrepretivist way (t=-4.49, p<.01). Moreover, students also tended to see scientific theory as invented rather than discovered (t=-4.49, p<.01; t=-4.59, p<.01). In brief, after a semester, students demonstrated a more informed understanding of the nature of scientific theory.

Table2. Understanding of nature of science.

Question	Code	pre-test		post-test		t-value
		M	SD	M	SD	
What is a scientific theory?	Subjective	0.33	0.73	0.92	0.90	-5.08**
	Objective	0.73	0.49	0.65	0.65	0.78
Is there a "better" or "worse" scientific theory?	Yes	0.65	0.84	1.33	1.10	-3.586
	No	0.83	0.62	0.77	0.90	0.425
How does a scientific theory form?	Constructivist progress	0.40	0.50	0.58	0.54	-4.491*
	Objective progress	0.63	0.49	0.62	0.57	0.191
Is scientific theory innvented or discovered?	Innvented	0.54	0.73	1.72	1.03	-4.491**
	Both	0.37	0.60	0.38	0.80	0.519
	discovered	0.63	0.69	0.37	0.69	1.756
Why do we need scientific theory?	Explanation	0.86	0.45	0.83	0.58	0.178
	Improvement	0.29	0.50	0.77	0.61	-4.599**

* p<.05 ** p<.01

Conclusion

In summary, the findings indicate that students changed their understanding regarding the nature of scientific theory after the study. In the beginning of the semester, students thought that theories were discovered and they regarded theory as a "truth" that cannot be changed. Also, students considered scientific theory as only objective explanation of phenomena in the world. However, after the semester, students thought that theories could be subjectively changed and improved and also was likely to be invented though personal imagination and collaborative innovation. In addition, students thought that theories not only can help explain the world but can help improve living technologies and human life. In conclusion, after engaging in collaborative learning for a semester, students' understanding of the nature of scientific theory changed from a more traditional view to a more constructivist-interpretivist way. In future research, we will focus on "how" students changed, and further analyze their collaborative learning process during this course.

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Supporting Self-regulated Learning with Moodle Forums

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Abstract: The present study investigates effective approaches to facilitate college students' self-regulated learning. Moodle forums were employed as a platform for students to develop metacognitive skills in the learning of psychology, and digital concept mapping was used to measure their conceptual knowledge. The findings suggest that discussions on Moodle forums enhanced students' awareness of their learning processes and facilitated the development of metacognitive skills. Active participation in such discussions promoted knowledge construction in concept mapping.

1. Introduction

Self-regulated learning is crucial in successful knowledge acquisition. It refers to self-directed actions in which learners transform their mental abilities to attain goals (Zimmerman, 2000). To learn in a self-regulated manner, learners need to monitor their effectiveness and improve their methods of learning accordingly. Since self-regulated learning processes require in-depth reflection and sufficient motivation, they can be challenging for individuals to achieve. Powerful learning environments can be facilitators for the acquisition of self-regulatory skills (Boekaerts, 1999). Research has shown that technology-enhanced learning environments can help promote self-regulation in structuring knowledge and incorporating new information (Dabbagh & Kitsantas, 2005). However, it is still uncertain how we can effectively make use of them to facilitate self-regulated learning. Thus, the present study aims to answer this question by employing a widely used online learning management system, *Moodle* (Modular Object Oriented Dynamic Learning Environment).

Based on the basic account of social constructivism (Bauersfeld, 1995), *Moodle* supports a variety of online activities to make it easier for students to interact in real-time as a learning community, give each other feedback on their learning difficulties and provide support among themselves (Martin-Blas & Serrano-Fernandez, 2009). While most previous work on Moodle mainly focuses on its usability, few studies have evaluated Moodle's impact on students' learning processes. With an emphasis on self-regulated learning, the present study explores how to utilize Moodle to enhance learners' metacognitive skills and improve their conceptual learning. In particular, *Moodle forums,* an important tool for collaborative activities are used in this study to answer two research questions: 1) How do students' self-regulated learning strategies develop via participating in Moodle forum discussions? *and* 2) How does the development of these learning strategies relate to students' knowledge learning?

2. Methodology

Twenty-three college freshmen in a major Midwestern university participated in this study (mean age=17.5). They were enrolled in an introductory psychology course and none of them had taken any psychology classes before. All students were admitted into a special program in the university for being recent immigrants or from low SES families. The majority students were non-native English speakers (18 Hmong, 2 Chinese, and 3 African Americans). Over a span of 16 weeks, the students attended lectures twice a week, and each week they learned one chapter in the textbook *Psychology* by David Myers (10^{th} Eds). They were required to finish weekly homework that consisted of two components: Moodle forum discussions and concept mapping. First, a Moodle forum was designed each week for students to reflect on and share their study strategies as well as giving each other feedback. Upon completion of the discussions, students were expected to construct a concept map (Novak & Gowin, 1984) with the Cmap Tool (http://cmap.ihmc.us/download/) based on the content they learned in the corresponding week.

Students' self-regulated learning skills were measured by their discourses on the forums. The forum posts were entered into a spreadsheet and analyzed with the *grounded theory* approach (Glaser & Strauss, 1967) to identify the self-regulation strategies employed. To evaluate students' conceptual learning in psychology, the weekly concept maps were analyzed with the *relational scoring methods* (McClure & Bell, 1990). The propositions were entered into a spreadsheet and then scored based on their completeness and correctness. Computer-based concept mapping provides learners interactive access to knowledge elements and resources represented by means of diagrams, and learners cognitive processes are thus exteriorized and visualized, which makes it more convenient to structure knowledge and regulate learning (Jonassen, 1992). Therefore, using concept maps as an assessment tool in this study can help obtain information regarding students' conceptual understanding and levels of knowledge management.

3. Results and Discussions

On the basis of previous work by Zimmerman and Pons (1986), six strategies emerged from the analysis of students' forum posts (see Table 1). Preliminary results reveal that, throughout their participation in the forum discussions, students' self-regulation gradually transitioned from concerns regarding external factors (e.g., distractions in the environment) to internal factors (e.g., improving content learning skills). In particular, during the first three weeks, most participant students initiated their discussions with a heavy emphasis on concerns about time management and how to avoid external distracters. While a few students shared their strategies for content learning, the majority showed uncertainty about applying effective basic study skills. This trend was gradually replaced by increasing discussions that tap into the learning of course content. Starting from the fourth week, students became apparently more aware of evaluating each other's study strategies, and sharing their own experience in understanding a certain challenging topic or applying mnemonics to memorize vocabulary.

Table 1: Self-regulated Learning Strategies Used by the Participant Students

Categories of Strategies	Example Responses
Time Management	*I didn't have enough time to finish the reading. I should start early next time.*
Avoiding External Distractions	*It's better that you go to the library to study as it is much quieter there.*
Seeking others' help	*I want to join a study group as studying with others helps me understand the textbook better.*
Keeping Records	*I jot down things I do not understand during lecture and look them up later*
Rehearsing and Memorizing	*I reread the textbook twice to help me remember the vocabulary.*
Using Complementing Materials	*I'd suggest you use flashcards together with the study guide.*

Based on the frequency of emerged self-regulation strategies being discussed in the forum posts, students were categorized into two groups: High Self-regulation and Low Self-regulation. Preliminary analysis of students' concept maps shows that, although there was no significant difference between the two groups in the number of propositions included in the concept maps, the high self-regulation group scored significantly higher than the low self-regulation students. In other words, students who more actively shared their study strategies and evaluated others' learning showed better understanding of the concepts and their relationships. In comparison, those who were experiencing difficulty monitoring their own learning or commenting on others' posts tended to have more wrong propositions in their concept maps. Besides, the structure of their concept maps showed fewer knowledge connections and hierarchy than the high self-regulation students.

The present study takes a first step to exploring Moodle's role in facilitating students' self-regulated learning. The findings, although preliminary, reveal how engaging in Moodle forum discussions may influence the development of self-regulated learning strategies. More importantly, by introducing digital concept maps as an assessment tool for learning outcome, this work provides important implications for postsecondary teaching and learning in the subject of psychology.

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Using a Graphical Interface to Address New Post Bias in Online Discussion Forums

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Abstract: This study investigated whether students exhibited different new-post reading behaviors when using a graphical discussion forum rather than a traditional text-based linear forum. Detailed examination of clickstream patterns in seven case studies showed several differences in reading strategies between the two forums. Most notably, in the graphical forum students read new posts in connection with other related (new or existing) posts, while in the text-based forum new-post reading was disconnected and scattered.

Introduction

In the context of increasing online and blended courses in higher education, online discussion forums have become an important component of many university class experiences. Despite the potential benefits for supporting collaborative knowledge construction, online discussion forums have some typical shortcomings. One problem in many online discussion forums is that participants tend to only read posts that are flagged as new, and only reply to the most recent posts in the threads ("new post bias," Chan et al., 2009; Hewitt, 2003). While it is important for students to read new posts as sources of new information, if students read *only* new posts, they may not be able to connect the ideas in the new posts to the content of the posts they have read previously. Thus, re-reading or skimming earlier discussion posts (even if read in a previous session) before reading more recent ones can help students to understand lower-level posts in context and avoid problems such as conversational drift, inadvertent thread death, and disregard for difficult questions (Hewitt, 2003).

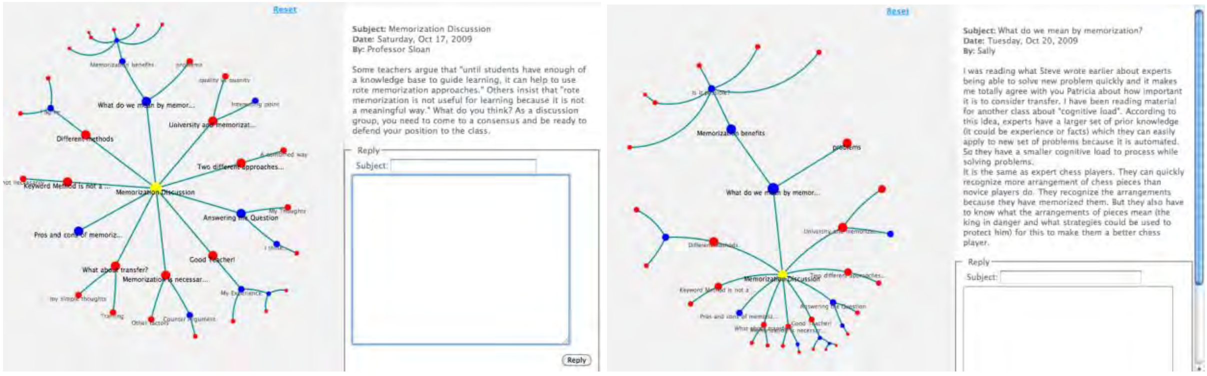
While multiple factors contribute to new post bias, several scholars have pointed to the standard linear text-based discussion forum interface as a major cause (Hewitt, 2003; Swan, 2004). Following from this, Hewitt (2003) suggests that redesigning the interface may help prevent new post bias and its negative educational consequences. One promising redesign solution is a (non-linear) graphical interface that highlights the structure of the discussion instead of the chronological order of posts and reduces the emphasis placed on new-post flags. In this study, we investigated whether such a graphical discussion forum produced different student reading and replying behaviors than a traditional text-based linear forum with respect to new post bias.

Graphical Interface

Figure 1 illustrates the graphical forum used in this study (Marbouti & Wise, 2013). The screen has been divided into two main areas: the graphical area (on the left), which represents the posts and their reply structure, and the content panel area (on the right), which contains the posts' content and the reply form. In the graphical area, a node represents a post, and a link between two nodes represents the reply relation between two posts. Node size has been used to represent different levels of posts. In this graphical presentation, the discussion prompt and its top-level replies are presented by bigger nodes and more space is allocated to them, while lower-level posts are represented by smaller and closer nodes (see Figure 1a). Thus the learner can focus on a part of the discussion, while other parts are still visible. When a learner chooses to explore a branch of posts by selecting one, the selected post moves to the center and its replies are presented as bigger nodes (see Figure 1b). In this presentation, the learner can see the entire discussion and easily visualize the relations between posts and decide which posts to open, theoretically support more purposeful reading and replying behaviors by students.

Methods

Participants were seven masters students who enrolled in an offering of a graduate course in which students met once a week and participated in online weekly discussions. This study took place two years after the course and participants were asked to engage with the graphical discussion in two sessions (equivalent to discussion log-ins). In the first session all posts were flagged as new. In the second session, a number of new posts were added to the discussion but the ones participants had read in the first session were no longer marked as new. In each session participants were asked to read some posts and make at least one post. A detailed log of all actions taken and think-aloud data was recorded. Participants' log data during their participation in the same discussion in the original course (text-based interface) was extracted from the archived system for comparison. Log-file data was analyzed to produce microanalytic accounts of participants' reading behavior in the graphical interface in both sessions and compare these with accounts of their behavior in two (comparable) sessions from their archived linear discussion forum activity. For details of microanalytic approach and procedures see Wise et al. (2012).



(a) (b)

Figure 1. Graphical discussion forum including the graphical area and the content panel showing (a) the initial discussion prompt post and (b) a reply that has been selected to read (Marbouti & Wise, 2013).

Results

In general, students showed interest in reading primarily new posts, regardless of which interface they were using. However, their strategy in reading new posts differed between the two forums, and also between students. In the graphical forum some students made an effort to re-read higher-level posts that they had read previously before reading their new replies. For example, one of the students, David (pseudonym), was interested in reading new posts; but as he described in the think-aloud, he decided to read the higher-level parent posts first (to refresh his memory about their content) before reading their new lower-level replies. This shows attention to reading posts in a connected fashion. In contrast, in his last session in the text-based forum David only read new posts from end of the list in a linear pattern, showing a classic example of new post bias.

There were also differences between the two interfaces in students' reading patterns even when students only read new posts. In the graphical interface, some students read the new posts in a connected fashion, viewing new top-level posts in each thread first and then their new lower-level replies. This suggests that even though students were interested in reading solely new posts, they were aware of the structure of the discussion and did not make their decision based *only* on the newness of the posts. In contrast, students in the text-based forum who read only new posts consistently ignored new top-level posts, immediately jumping to new lower-level reply posts. Thus their reading pattern was disjointed as they read posts in isolation from the context of the discussion. While one student in the text-based interface did mostly re-read posts that he had read previously, these posts were also scattered throughout the forum and not part of a connected series.

Conclusion

This study investigated differences in students' reading behaviors in graphical and text-based discussion forums. The results documented the strong presence of new post bias in the linear text-based forum, instantiated as the reading of new and scattered posts. In the graphical forum students still focused on new posts; however, this often manifest as connected reading of new posts from higher-level to lower-level ones. This finding has led us to refine our consideration of the problem of new post bias to focus on the connectedness with which any posts (new or previously read) are accessed. In this respect, the graphical interface presents a promising mechanism for addressing the negative educational aspects of new post bias.

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Navigating online learning environments in the classroom

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Abstract: Possibilities and challenges inherent in networked learning environments call for ways of looking at teacher use of online spaces. We share mixed method research of two teachers and their students in a citizen science program. Although the teachers had similar levels of success with the program, they interpreted the purpose of the online environment differently. One used it as a space for students to publish perfected work while the other used it alongside students to build knowledge and foster community.

Introduction

Online learning environments are rapidly becoming part of the education landscape for K12 (Queen & Lewis, 2011), including customizable platforms that incorporate social network forums. And although more research is needed, studies suggest that interactions online in both formal and informal environments can lead to outcomes related to learning and engagement (Fredericksen et al, 2000; Pawan et al, 2003; Guzzetti, 2006). However, there is also a growing concern that new information technologies may contribute to further inequalities along economic, cultural, or gender lines because of differential use, attitudes, or skill (DiMaggio et al., 2004; Hargittai, 2008). Given these potential outcomes and challenges, we need more ways to explore interactions, learning, and engagement online.

In this work, we use a blend of automated and qualitative data to look at middle school teachers and their students within Vital Signs, a networked citizen science platform specifically designed for use in in classrooms around Maine. Online citizen science environments have the potential for collaborative knowledge sharing and community building around ongoing data collection and analysis. As such programs are incorporated into classrooms, can teachers broker global collaborative possibilities or are they simply gatekeepers of usernames and passwords? What types and patterns of online interactions create opportunities for and evidence of learning across multiple levels of analysis, including teachers, students, and community? This work is part of a larger research effort to learn more about teacher and student practices and engagement in cyberlearning environments. We use mixed methods to look at classrooms across space (school and online), time (multi-month) and scale (community, class, and individual).

Methods

During the Vital Signs unit students go into the field and use digital cameras and GPS receivers to collect data on native and invasive species in their local ecosystem. The website is designed to help users organize and submit their own observations, analyze existing data, and view and comment on the work of others. Professional and citizen scientists, considered species experts, confirm or question investigation data.

We recruited two teachers (A and B) who had used Vital Signs in the classroom for two years and were highly engaged with the program. We followed two classes for each teacher (N=98 students) monitoring online activity and observing classroom and outdoor activities. Students of teacher A submitted individual work (48 accounts) while students of Teacher B submitted work as teams of four (12 accounts).

Online data. Participation data from the Vital Signs site was collected for each teacher, including personal investigations submitted and missions (investigation foci for students), resources, and comments posted. All comments made to or by students in the focal classrooms were captured and a visual representation of the commenting patterns for each teacher and their students was created (see Figure 1).

Teacher interviews. A semi-structured interview protocol was designed to provide teacher reflections on their history as a science teacher and their personal and classroom experiences with the Vital Signs program. The teachers were interviewed (35-55 minutes) at their schools.

Results

Teacher perceptions and participation. For teacher A, the Vital Signs site was an informal window into scientific practice for both him and his students to post work, receive feedback, ask questions, and explore. He submitted seven observations of his own and created ten different missions on the site to guide his students' observations. Teacher B, in contrast, saw the Vital Signs site as a formal public presentation space for students to post polished scientific work that had been critiqued, revised, and perfected in the classroom. She had not submitted her own investigations and used missions predefined in Vital Signs.

Teacher comments. Teacher A was a central hub of activity connecting to the students in the online environment through encouraging comments on their work: "*Your field notes are well detailed and tell the whole story. I noticed that others have avoided the sketch as part of their submissions. Maybe you could be a* *sketcher for hire. You have some artistic talent for sure."* He commented on 44% of the submissions from the focal classes, while teacher B did not comment on student work (see Figure 1).

Student comments. Teacher A offered class time for students to view the work of others and leave comments. Across his classes, 29% of user accounts posted comments on other students' work (including those in other classes and schools) and 35% received peer comments on their own work: *"Jamie! Nice job. I love your pictures there really pretty :)."* Teacher B did not introduce commenting in the classroom. Two user accounts (17%) posted comments on work submitted from another class and none received peer comments. Although Figure 1 does not show all expert scientist comments, it does show when students responded to an expert scientist, which was the most frequent type of interaction for Teacher B classrooms (three instances, 25%), which were often more formal in tone.

Student science learning. We are in the process of coding the quality of student work submitted online from both classrooms and looking at data from student survey measures to compare the classrooms in terms of submitted work and engagement in the program and science learning more generally.

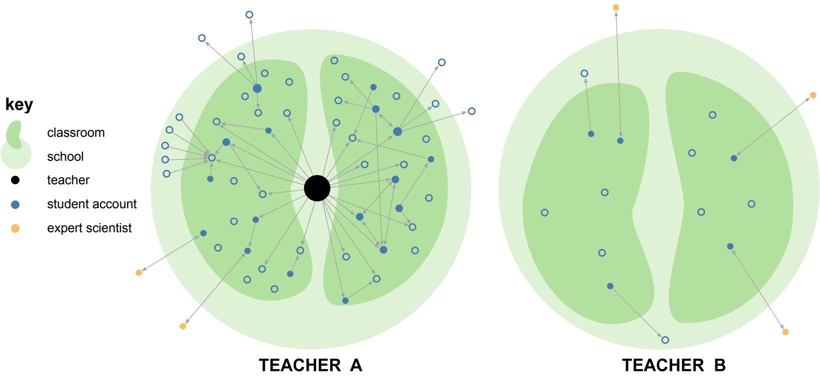

Figure 1. Visualization of comments to and from student Vital Signs accounts for teachers A and B. Filled nodes indicate at least one outgoing comment. Size of node indicates number of outgoing comments.

Summary and future plans

In this preliminary study, we find that teachers interpreted the public and scientific framing of Vital Signs differently. One saw it as an opportunity for students to publish professional and depersonalized scientific observations during a fixed classroom assignment and formative feedback was not public. Another saw the site as a portal for himself and his students engage in a citizen science community of knowledge sharing and building. He expected student work to improve over time and across multiple investigations and used online comments to provide formative feedback and encouragement. Comparing investigation artifacts and survey data from students in these classes is a next step in this work in order to explore potential implications of different teacher approaches to online communities used in the classroom.

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Design methods to study learning across networked systems, co-located spaces, and time

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Abstract: The 2013 CSCL conference theme—investigating learning across levels of space, time, and scale—has becoming an increasingly important issue with the proliferation of new types of networked learning environments. In this paper we share our approach to studying and designing for learning across settings and time, grounded in an investigation of a citizen science program that takes place in the classroom, outdoors, and online.

Introduction

Networked technologies have made new genres of learning environments possible, at least for schools that have access to the Internet, computers, and professional development opportunities for teachers. Online learning communities that connect participants with one another have generated the need for new design frameworks. In particular, how we can best design systems to capture learning-relevant interactions, take advantage of tools, and develop design approaches that consider how varied users feel about the online spaces and how these feelings relate to their own biographies. In our project we develop both teacher and student learning biographies as we know that even when access to tool and networks are provided, variability in how teachers and young people use technologies at home may influence how tools are taken up at school (Forsell, 2012; Warschauer, 2008). In this paper we share our approach to studying and designing for learning across settings and time, grounded in an investigation of a citizen science program where learning interactions take place in the classroom, in outdoor settings, and in an online community.

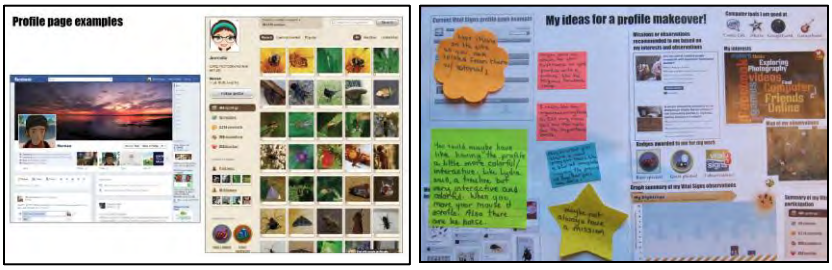
Methods

To do this work, we partnered with Vital Signs, a networked citizen science project involving middle school students, teachers, and amateur and professional scientists. During the classroom unit students go into the field and use digital cameras and GPS receivers to monitor freshwater, upland, and coastal ecosystems for native and invasive species. The website is designed to help students organize, upload, and analyze their data and to connect them with scientists who confirm or question their investigations. Four science teachers were recruited to represent a range of engagement with the Vital Signs work and school economic profile.

Our multi-method study is guided by a learning ecology framework (Barron, 2006). Expanding our notion of spaces for learning requires that we broaden our units of analyses to track a learner's participation in learning activities not only in school but at home, in the homes of friends, in neighborhood contexts, in community based organizations, and increasingly in online environments that offer new forms of activity and resources for learning. We used four main empirical strategies to understand and contrast the system at multiple levels: (1) Cohort studies using quantitative survey measures (N=217); (2) classroom case studies, using in class and online observation; (3) individual teacher (N=4) and student (N=16) case biographies documenting interests, family life, and Vital Signs experiences; and (4) co-design methods that asked learners (N=27) and their parents (N=11) to react to and redesign components of the Vital Signs online site. Due to space constraints, we focus on our co-design methodology and share select findings to illustrate our approach.

Co-design methodology

Co-design methods are frequently used in human-centered software design (e.g. Norman & Draper, 1986). We set up a collaborative model of design where groups of parents and students worked together on a design and used this data to guide our understanding of the networked system and the people who use it (similar to "personas" in co-design work by Pruitt & Grudin, 2003). A small group after school workshop was developed to invite youth as partners in the redesign of the original, rather basic, Vital Signs profile pages. Students from our focal cohort attended and case learners participated in a later session with their parents. Materials included paper-based profile page examples and blank profile templates (see Figure 1a) to guide discussion. Paper profile page elements were generated based on student interviews about interests and behaviors online, including a tag cloud of interests, a map of individual investigations, and visual documentations of work. These were cut out as separate pieces and each student was given a set. Each group was provided post-it pads, markers, and glue sticks. Groups discussed profile pages and likes and dislikes of particular features, then brainstormed their own ideas, and sorted through the pre-designed features and pasted their choices onto their new profile designs with additional ideas and annotation (see Figure 1b).



Figures 1a and 1b. Co-design workshop materials, including sample profile pages (1a) and a completed profile page "makeover" designed by a student (1b).

Results and an example of co-design partners: Laura and her mother

Our cohort data revealed students, on average, to be regular Internet users: 97% reported home Internet access and frequency-of-use is similar to recent national surveys: at least once a week, 89% used the Internet to find information, 68% used a social network site, and 56% played computer games. Although the majority of students (63%) reported that they looked at plants around them differently after the Vital Signs unit, few revisited the website community after they submitted their investigation (12%). We were able to learn more from individual interviews. The Vital Signs program was intentionally developed to engage students in a scientific community of practice, but students saw the site as "an adult site, like adults would go on." Our student design partners revealed a desire for a more personalized and social space, sparking ideas about the development of more interesting and engaging profile pages. During the profile page design workshop, we learned still more. Some students were on multiple social networking sites, but 22% of participants were not involved in any. Ninety-four percent chose to have badges on their profile page to represent what they had done in Vital Signs and 89% wanted their profile to include a geographical map of their investigations.

One co-design case student, Laura, lived with her parents and three siblings in a rural setting. She reported that she definitely could not see herself becoming a scientist when she grew up. Other indicators, however, such as her stories about looking closely at the natural world around her, suggest a more complicated picture of the role of science in her life. Laura enjoyed taking digital photographs and using Instagram. Some of her design ideas for Vital Signs profile pages sites utilized photo-sharing site features such as, "different kinds of filters." and "be able to adjust lighting + contrast to make photo clearer/better!" Others called on social network components such as being able to "post on other people's walls like on Facebook" and "compare to other people like you." Laura's mother had compelling ideas as well. Given a need for quality summertime childcare and financial constraints, she suggested a free virtual camp where youth could collect and discuss observations in their backyards and connect to scientists and resources.

Summary and implications

In this paper we argued that biographical and co-design methods are critical for understanding participation in networked learning opportunities and for generating new ideas for the design of such environments. We shared our approach to show exciting potential for learning within authentic activities as part of hybrid school-online programs like Vital Signs and the importance of finding multiple ways to connect to learner interests and families through cyberlearning.

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Beyond sociograms inspection: What social network analysis (SNA) has to offer to measure cohesion in CSCL

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Abstract: Social network analysis (SNA) has emerged as a widely used approach to study structural aspects of collaboration. However, its techniques have not been fully exploited yet in CSCL. This paper presents the main results of a survey that focused on identifying the existing approaches for the study of cohesion in CSCL using SNA techniques. It also points out some challenges and future research lines in this area.

Introduction

Social network analysis (SNA) has been recognized as one of the relevant methods within the multiple analytic voices in CSCL (Suthers et al., 2011). The number of papers dealing with SNA presented in recent CSCL conferences reflects this interest (Reffay & Martínez-Monés, 2011).

SNA provides indicators and visualizations to gain insight into the structural properties of interaction, as well as into the ways these properties affect the individuals. However, despite its apparently simple and intuitive techniques, SNA is also a broad and complex research field in its own right. Researchers need to be aware of the rules and conventions of SNA when applying it to their work.

This work aims to shed light on how SNA has been used to measure cohesion based on empirical data from educational settings and guide future research in the area.

Method

We reviewed the literature on the use of SNA to analyze interaction in computer-supported educational settings. The first finding was that researchers had paid relatively less attention to the study of cohesion than to other network properties, such as centrality and position.

Cohesion is considered in collaborative learning as an important factor for motivation and effectiveness. Dense and cohesive networks have the potential to facilitate fluid flow of information, ideas and resources among participants, which in principle is conducive to collaboration. However, it is unclear whether and how this is being studied in CSCL and to what extent these potential benefits apply to CSCL. In order to delve into these issues, we focused this study in the following questions:

- Which SNA methods have been proposed to measure cohesion in CSCL?
- What are their main findings in terms of the influence of group cohesion in learning?

Results and findings

Once the focus and dimensions of this survey were set, we reviewed 143 papers to identify those dealing with cohesion. A total of 41 papers were selected. These were classified according to the data source(s) employed to build the network and to the technique used to measure cohesion. The detailed categorization of these selected papers is available as an online appendix (1). Table 1 shows a summary of the number of papers found in each category.

We distinguished four main approaches to measure cohesion in SNA: (1) sociogram inspection to analyze the network structure and groupings; (2) indexes such as cohesion index and network density and centralization; (3) identification of cliques and clusters; and (4) cut-point analysis and identification of bridges. The reviewed works posed research questions related to the relationship between group cohesiveness and the quality of knowledge construction, as well as more specific questions, such as the existence of an homophily effect, that assumes that similar people tend to join together. The research approaches varied from hypothesis testing to more descriptive mixed-method studies, where SNA was used to complement other data sources.

The data sources used to build the networks were predominantly asynchronous forum discussions and collaborative knowledge building discourse. Many current tools used to conduct automatic SNA use forum data as their input. Other data sources, especially those that characterize interaction in Web2.0 are rare. We also found that there is a tendency to not specify sufficiently how the networks are built from the data sources. Many studies take the meaning of the links almost for granted. Others, like Goggins (2010), show that many subtleties exist and need to be made explicit, as they have an impact on the interpretation of the analysis.

Table 1: Number of papers found for each group of cohesion techniques and data source. Some papers count more than once, if they apply more than one technique or/and deal with different data sources.

Data source \ Techniques (Total of distinct papers = 41)	Sociogram inspection for cohesion (16)	Numerical indexes: Density Cohesion and centralization (24)	Groupings: Components, Cliques, Clusters (19)	Cut point analysis, bridges (4)
Discussion Forum (21)	6	11	12	2
Document sharing (8)	5	4	2	2
Wiki (1)	1	0	0	1
Blog / shared profiles (3)	2	1	2	1
CSILE or KF (7)	3	5	2	0
Chat (1)	0	1	0	0
e-mail (2)	1	1	2	0
Twitter (2)	1	2	0	0
Integrated data (2)	1	0	0	1

Conclusions

SNA is becoming an accepted analytic approach in CSCL to measure structural properties of collaboration in learning settings. This dimension is becoming even more prominent now, with the rising popularity of MOOCs (Massive Open Online Courses) and other community-wide learning events. The first finding of our literature review is that the vast majority of the reviewed papers deal with centrality and positions of individuals in the network. Less than a third of them were studying cohesion.

In terms of the interpretation of the results, we have found little consensus in the relevant literature on the implications of cohesion for learning in general. Although it is regarded as a desirable characteristic of a group, some of the reviewed works found out that cohesion indexes where negatively related to knowledge construction variables, while other obtained positive results. This does not mean that SNA is inadequate for studying these structural aspects of learning and collaboration, but that its findings need to be interpreted in the contexts they were generated. It seems to us that there is room in this direction for research to better identify the impact of cohesion on learning in its various contexts.

This is related to another conclusion of our work: more care should be taken in considering the implications of each particular network model on the interpretation of the results. Accordingly, we implore researchers using SNA methods to pay special attention to describing the network models they are applying and how they are built from the raw data. Despite the wide range of possible and emerging data sources (social media, blogs, tweets, etc.), asynchronous discussion forums remain the most commonly studied ones. Furthermore, even if different sources are considered in a number of works, they are mostly considered separately. One specific aspect that has been neglected so far in the studies is how to combine them and use multiplexity to gauge the strength of ties between people according the variety of relationships rather than merely the quantity of interactions in a particular medium. Many CSCL interaction studies employ different mediating tools, and this provides an excellent opportunity to study multiplexity as an index of the collaboration in educational settings.

Acknowledgements

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Endnotes

(1) http://gsic.uva.es/docs/CSCL2013/MartinezReffayTeplovs_Appendix_CSCL2013.pdf

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Idea Development in Multi-touch and Paper-Based Collaborative Problem Solving

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Abstract: Multi-touch technology has the potential to support collaboration, although there is little evidence about how collaborating using this technology differs from collaboration with traditional materials. In this paper, we examine the interaction behaviors of four groups working with a multi-touch table, and four groups working on a paper-based version of the same task. Results indicate that more ideas are introduced and developed by students in the multi-touch condition.

Introduction

Multi-touch surfaces have the potential to change the way collaborative learning occurs (Higgins et al, 2011). As this technology allows multiple users to interact simultaneously with the content on a shared screen, it may allow more equitable participation of group members. Initial research on this technology indicates that, when compared to a single-touch surface, groups using multi-touch engage in more task-focused and less process-focused discussion (Harris, et al., 2009). Additionally, when compared to paper activities, students using multi-touch have been shown to have higher levels of joint attention and more interactive comments (Higgins et al, 2012). However, there is still much to be understood about how interaction changes when there is equal access to content.

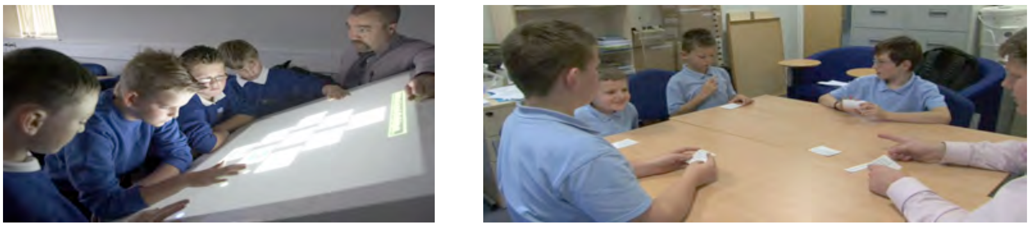

Figure 1. Groups working in the Multi-touch and Paper-Based Conditions.

Method

This study was a within-subjects design, with groups completing activities in both the multi-touch and paper-based condition during a single visit to the research lab. This paper draws on data from one of the mathematics activity that was completed in either a paper-based or multi-touch condition.

Participants

Participants were 32 10-11 year olds who were recruited from two local schools. Groups of eight came to the lab and worked in same gender groups of four. On arriving at the lab students become familiar with the multi-touch tables. Then one group worked on a paper-based history task, while the other group worked on the same task on multi-touch tables. The groups then switched conditions, and worked on math mysteries. Two members of the research team were involved; each taught half of the paper-based and half of the multi-touch activities. Teachers worked with the groups, intervening when groups appeared to be struggling.

Math Mystery

The groups completed a math mystery that focused on number knowledge, asking them to reason through a series of clues about which hotel room a stolen statue had been hidden in (e.g. "The answer does not contain the digit 3"). In the paper-based condition, each clue was presented on a piece of paper, while in the multi-touch condition, the clues were on digital paper, which could be moved and re-sized on the screen.

Coding Scheme

An emergent coding scheme was developed, drawing on prior research on collaborative mathematical problem solving to inform codes that would represent the types of interactions evident in the data. There were three stages to the coding scheme. In the first stage, the unit of analysis was identified. This was defined as an idea, and began when a new idea (or clue) was introduced, and ended when the group moved on to talk about a different idea. Two of the transcripts were double coded in the first stage, with agreement of 83%. In the second stage, the person introducing and engaging with the idea was identified; double coding of one transcript indicated 100% reliability. In the final stage, student engagement was classified as denoting importance, combining clues or expanding clues (see Table 1). Double coding of one transcript indicated 85% reliability.

Table 1: Phase Three of the Coding Scheme

Code	Definition
Importance	Responses comment on importance of a clue, but do not elaborate.
Combining clues or ideas	Student combines clues or ideas to the introduced idea to build on it.
Expanding	Student expands or elaborates on an idea or clue.

Results

Results indicate that there were more ideas proposed in the multi-touch condition (M = 17.75, SD = 4.65) than in the paper-based condition (M = 14, SD == 1.41). Drawing on the second stage of coding, figure 2 shows who responded to the ideas, indicating that more ideas were introduced by students in the multi-touch condition, for all categories. Teachers introduced more ideas that students responded to in the paper-based condition.

To examine how students responded to the ideas proposed by other students, we categorized the responses into, commenting on the importance of an idea, elaborating on the idea, and combining the idea with other ideas to move the group forward in solving the problem. When the number of types of responses was examined as a proportion of the total number of ideas, results indicated that there is little difference in recognition of importance (12% for paper; 14% for multi-touch). Students in the paper condition combined ideas more often (20%) than students in the multi-touch condition (15%) while students in the multi-touch condition elaborated on ideas more often (21%) compared to students in the paper-based condition (16%).

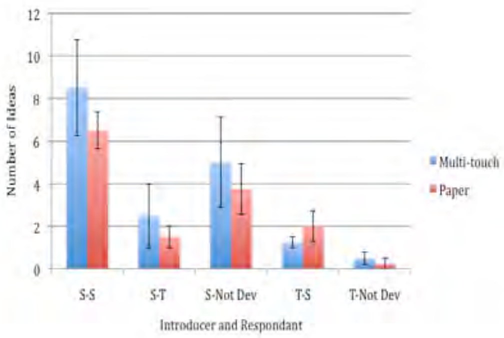

Figure 2. Introducer and Responder to Ideas (S = Student; T = Teacher)

Discussion

We set out to examine idea development in groups working in a paper environment and groups doing the same task on a multi-touch table. Results indicated that there were more ideas introduced in the multi-touch condition than in the paper condition, suggesting that there may were different types of interactions.

Responses to ideas were coded in terms of who responded, and when examined as a proportion of total ideas, there was little difference between the two conditions, indicating that interaction levels were similar in the two conditions. However, when types of interaction were examined as a proportion of total ideas, the results showed that students in the paper-based condition combined ideas more often than students in the multi-touch condition, while students in the multi-touch condition elaborated on ideas more often. These differences suggest that there were different types of collaborative engagement occurring across conditions, with students in the paper-based activity being slightly more focused on putting together the ideas to reach a conclusion. Students in the multi-touch condition focused on making sure that the ideas were re-interpreted, perhaps to ensure all group members agreed on the meaning of the ideas before they moved on. This difference in types of interaction indicates possible ways in which the task medium may have influenced collaboration, and suggests that groups in the multi-touch condition may be more concerned with building a joint problem space than those who used paper. This study adds to our understanding of how using multi-touch technology may influence collaborative interactions, which is essential to our understanding of how to design learning activities that use this technology.

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Collaborative Learning in Virtual Environments: Role-based Exploration of Causality in Ecosystems over Time and Scale

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Abstract: EcoMUVE is a middle school science curriculum that provides an immersive virtual eccosystem in which students learn about complex causality through collaborative inquiry activities. We describe case study research focused on EcoMUVE's supports for collaborative learning, including a jigsaw pedagogy and in-world supports such as chat and data sharing.

EcoMUVE, a research project funded by IES, has developed a curriculum for middle school students to learn about complex causal relationships in ecosystems using Multi-User Virtual Environments (MUVEs). This poster presents exploratory research on the multi-user aspects of EcoMUVE – supporting student collaborative learning in a model that blends face-to-face dialogue with interaction in immersive virtual environments.

EcoMUVE Forest is a two week, inquiry-based curriculum unit centered on an immersive virtual ecosystem that includes two forested islands. Students travel in time over five decades to see changes in populations and forest structure, and to figure out why fewer visitors are coming to one of the islands. The unit uses a jigsaw pedagogy in which a team can succeed only if each student contributes data for which they are responsible, and all team members collectively interpret that information. Students observe plants and animals, shrink to view microscopic organisms, collect data, and graph changes in the populations of different species. They work in 4-person teams, each choosing a role (e.g., botanist, bird watcher). Students work individually on computers on role-specific learning tasks and data collection, collaborating through online chat and data sharing, as well as face-to-face in team meetings. The unit culminates in each team creating and presenting to the class an evidence-based concept map that represents their hypotheses of the ecosystem interrelationships.

To look in depth at students' collaborative learning, we designed a case study around a science teacher and four classes of 7th grade students (N=91), ages 12-13, who used the Forest unit over two weeks. Data collected included pre- and post-surveys, chat logs, video, and team concept maps.

The key features we will highlight on the poster focus on the affordances of the technology for scaffolding collaboration, including student roles, data sharing, and in-world chat. We will describe how the concept maps that students create, as well their class presentations, demonstrate their collaborative learning.

Findings

In post-surveys, 95% of students said that they liked their role, and 91% said they learned from their teammates. Most students included descriptions of things they had learned from their teammates, for example, a birdwatcher said "I learned from the Botanist about the changes in suitable bird habitats on the islands." A pre-post survey of content learning found statistically significant ($t(82)=8.38$, $p<.0001$) mean score gains of 3.512 points, representing an effect size of 1.04 standard deviation units.

Students used on-line chat with teammates (Figure 1) to ask for help ("wait how do u go to a different island?", "what do small mammals eat?"), determine roles ("I call botanist"), share information ("red tailed hawks are eating the other birds" "omg really???"), share data ("Everybody make sure to add everybody else on data"), and plan their presentations ("maybe u can graph songbirds or other birds and show what they eat.").

Teams primarily collaborated on their concept map face-to-face at a shared computer, inputting all team member data and looking at the full dataset using multi-line graphs over time (Figure 2). Sample video transcript:

> E: What do the wolves eat? Do they just eat deer, or do they eat small mammals too?
> F: We should check that out.
> [E opens small mammals page of online field guide, while A watches. E reads out loud.]
> E: when a single wolf hunts alone it hunts and eats smaller prey such as rabbits and other small mammals
> [E switches to graph, they select deer, small mammals, and wolves to display over time]
> E: So small mammals and white tailed deer are affected by the wolves.
> F: [points] Yeah, when this starts going down this goes back up, when this starts rising this goes back down.

During team presentations, students projected their concept map using a document camera projector (Figure 3, left) and took turns explaining the parts of the map pertaining to their role (colored, Figure 3, right). Overlaps show related concepts that students learned collaboratively. For example, the population specialist (yellow) discovered that without wolves the deer population increased. She worked with the botanist (green) to identify the overpopulation of deer as the reason there were fewer shrubs. The birdwatcher (purple) then explained the impact of the lack of shrubs on birds who use the shrubs as habitat.

Figure 1. Example of chat in EcoMUVE.

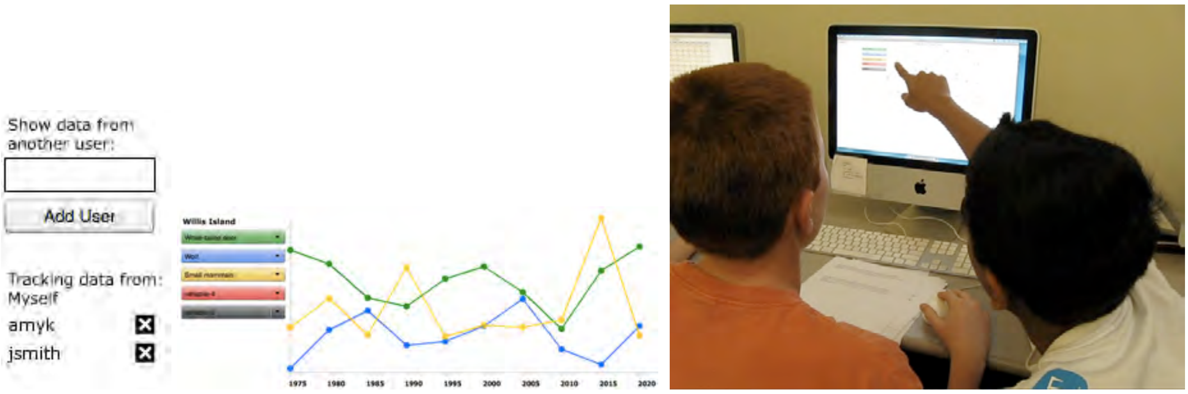

Figure 2. Sharing data interface (left), shared graph (center), student collaboration example from video (right).

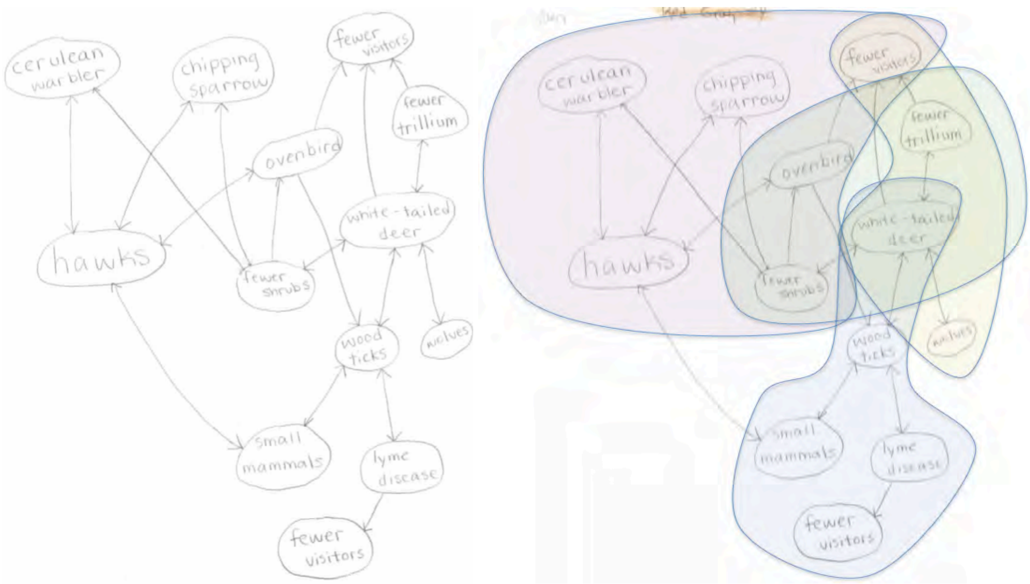

Figure 3. Example concept map, as drawn by students (left), colored to show overlapping roles (right).

Puppetry as a Catalyst in Role-Play: A Device to Facilitate Gaining New Insights into the Perspectives of Others

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Abstract: Role-play is a powerful learning strategy that promotes the learners to broaden their perspectives, especially in complex situations like classroom teaching. Using puppetry creates a psychological distance from the player's identity, and the players' anxiety for the evaluation apprehension is reduced. The case study of the puppetry role-play in microteaching shows that the players can play various roles as though in a realistic situation. The possibility of puppetry as a catalyst interface for face-to-face CSCL systems is discussed.

Introduction

Role-play is widely used as a method to provide students the opportunity to fully engage in the learning activity, and attain a variety of insights about the social, historical, or scientific phenomenon (Forsyth, 1999; Ladousse, 1989; Resnick & Wilensky, 1997). Role-play is also especially recognized as a suitable technique for the study of dynamic, complex, non-routine situations; in decision-making training such as crisis management, nursing or medical; and in teaching classrooms. One interesting aspect of these kinds of role-play is to emphasize improvisation rather than scripted scenarios. Improvisation in role-play is a particularly powerful learning strategy to achieve, in that biases can be overcome through the development of new beliefs (Friedman, 2004). This is because in such role-play, actors are sometimes required to behave counter-attitudinally, and those improvisations are often based on the role players' experience and reflections in part of their daily life.

The importance of such improvisations can be explained in terms of Bakhtin's theory of dialogism. According to Bakhtin (1986), all utterances can be seen as replies to the voice of another person who preceded him, since the speaker will take into account the listener's background knowledge, previous utterances, gestures, etc. in predicting the listener's likely refutation. In this way, one's utterance will be formed with the anticipated words of the listener in mind, while at the same time the follow-up response of the listener will also be foreseen. In this sense, it can be said that utterances themselves constitute dialogue. In this dialogic view, decision-making and negotiations in the complex situation is nothing other than the process of forecasting the reactions of the actors in the situation, engaging in hypothetical dialogues, and incorporating the results into how to deal with the situation. Thus, involving improvisation is crucial because the role-play requires the ability to vividly imagine a diversity of actors' voices that are rooted in the values and backgrounds of each participant.

However, some of the participants still cannot play their roles very well due to being overly self-conscious (Ladousse, 1989) or evaluation apprehension (Cottrell et al., 1968). For example, the microteaching role-play in pre-service training requires the participants to play their roles collaboratively as a teacher and young pupils, and to simulate an actual classroom in order to demonstrate teaching in a real-life context. However, the reactions and feedbacks provided by colleagues acting as pupils are sometimes out of context, since they must play the role of much younger people. Their reactions and feedbacks cannot be ensured to be serious, honest, or realistic due to embarrassment or hesitation.

Puppetry as a Catalyst to Facilitate Gaining Perspectives in Role Play

In order to scaffold the effective dialogic imagination in role-play, puppetry can be a useful device for allowing people to engage in the improvisation and elicit various reactions or responses from the participants.

The most important function of puppetry is that it allows each participant to obtain participant-observer balance and foster his/her participation by creating a clear separation between self (puppeteer) and non-self (puppet) while creating a puppetry story. The non-self, or puppet, also contains recognizable elements of the self which the puppeteer can identify with. Such projection in puppetry is considered to provide a 'margin of safety' manipulated by the puppeteer to achieve a balance between underdistance and overdistance (Aronoff, 2005). For example, it is possible for the puppets to "talk" about sensitive topics that would otherwise be unacceptable for an actor to discuss in a drama (Panford et al., 2001). Thus, puppets can be considered as a powerful distance device to elicit much more inner emotions or unconscious experiences regarding a problematic situation.

A Case Study of Puppetry in Microteaching Role-Play

The case study was conducted in microteaching (which is ill-structured problem solving situation) role-play, based on a "Desk top teaching simulation game" (Sakamoto, 1980) that took place on a table set up as a miniature classroom with puppets. The players were acted out as actual students in real situations. The players (two female and two male senior students) could not role-play realistic students very well in the microteaching exercise in the university class - even after their internship in the actual schools. In the case study, we decided to use animal dolls rather than human-shaped dolls in order to create a distance between the dolls and puppeteers' themselves in the role-play (see Figure 1 for details).

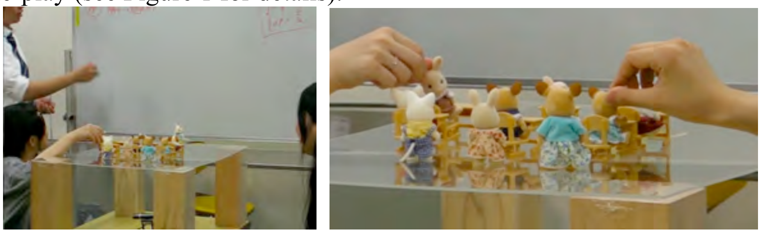

Figure 1. Scenes from the experiment
(Left male wearing a tie played a teacher; two females played students and the supervisor (at the right front))

As a result of a detailed analysis of the video of the case study, it was shown that (1) puppetry can elicit various roles that were not reflected the player's identity, such as slow or irregular students; (2) puppetry can duplicate backchannel in the classroom that sometimes supports student-centered knowledge building or fosters cooperative reciprocal teaching that cannot appear in microteaching by self-role-play; (3) puppetry can foster the players to conduct various roles using multiple dolls; and (4) puppetry can foster the players to express possible non-verbal actions using verbal expressions that can be recorded by computers or videos.

Conclusion

We have introduced the new possibility of puppetry as a device to facilitate gaining new insights on the perspectives of others in role-play, for learning about complex situations. Using puppetry creates a psychological distance from the player's identity so that the players' anxiety for the evaluation apprehension is reduced, and have presented empirically that the players can play various roles as if in a realistic situation. Especially in face-to-face collaborative learning, such as the tabletop collaborative negotiation (e.g. urban planning in Sugimoto et al. (2004), etc.), this will be an indispensable interface that should be a catalyst to elicit multivoice in inner emotional worlds or unconscious experience, and help learners to broaden their perspectives that blend the experience, knowledge and beliefs of multiple imaginary actors.

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Understanding the Life of an Online Community through Analytics

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Abstract: Online learning communities have existed and been studied for a long time now and changes in the nature of the Internet have changed the forms of these communities. The present study proposes to understand a little-investigated side of online communities, long-term structural changes. To that end, we present preliminary data and a plan of analysis that will uncover six-year changes in participation, leadership and member attitudes toward a blogging community of amateur athletes.

Introduction

Online communities have been a staple of the Internet since its infancy and have only seen a mercurial rise in the last decade in the form of social media, social networks, virtual worlds and many user-generated content websites. A peculiar characteristic of many such communities is that they are informal or non-formal in nature, created by an initiator or a small group of individuals who are joined by others over a period of time, to share, discuss, learn and otherwise engage in a topic of interest. Concurrent with the rise of these communities has been a rise in academic interest in their structures and outcomes. Several different lenses may be used to understand the mechanisms and culture of an online learning community – such as sociological, educational, economic, etc. The goal of these lenses is to understand the community's content and activity, patterns of participation and the resultant sociological, educational, economical, etc. outcomes. However, rarely is an online community studied over a lengthy period to uncover *changes* in content, participation and outcomes. The present study proposes to do just that.

Study Design and Initial Findings

Differences in participation are explained by Lave and Wenger's (1991) idea of a community of practice as well as Gee's (2005) idea of 'affinity spaces'. Both refer to participation in an activity of shared interest, with Gee's focus on space rather than membership. To some degree, both these characterizations seem to fit the community and space we are studying- a blogging community of amateur athletes (triathletes, marathoners and adventure racers). This community has existed for close to six years, has 12 member-contributors and 16 acknowledged followers. The blog is public. It was started by one founding member who wished to run a race as a fundraiser for a cause of his choice. Initial invitees included his lifelong friends and new members were added by invitation or recommendation. Understanding changes in participation in online communities is commonly done through Lave and Wenger's (1991) Legitimate Peripheral Participation model where the community is in a state of flux as far as degrees of participation are concerned and the movement is from a state of low to high participation until the member leaves the community (Bryant, Forte and Bruckman, 2005). However, we propose that this model overstates the likelihood of such movement in a community like the one in question. Similarly, the affinity space model (Gee, 2005), which often refers to massive online groups for illustration, is largely silent about the nature of participatory change other than acknowledging individual variation. So, neither Lave and Wenger's work nor Gee's view satisfy our need to model how participation brings about longitudinal changes to this blog.

In order to understand and model it, we chose to analyze the number as well as the content of every contributor's posts. To that end, Figure 1 depicts the former in terms of every member's contribution as a percentage of the yearly posts. According to the Lave and Wenger (1991) model, the lines depicting low initial participation (the community became operational in 2007) should rise higher as they move toward the right and closer to present day, and converge toward the middle. However, the activity of all but one of the members ('A') rejects this model. In all other cases, activity is either robust at the beginning of the 6 year period but gradually and consistently dips lower or stays steadily low throughout. In fact, although the graph includes data from 12 contributors, only 6 were plotted since contributions of the rest were consistently miniscule. These members may be termed 'lurkers' (Bishop, 2007) or 'listeners' (Wise et al, 2011) and the above model would suggest that their contribution would move them higher up in the graph as the years progressed. Clear evidence of their lurking is expressed by their replies to other members' posts mentioning them despite rarely making original posts of their own.

We are currently in the process of analyzing content over the 6 years, looking for trends in relationships between specific content and contributor, if any. In addition, we aim to better understand lurking/listening in the community by analyzing comments and page views per post. By connecting these dots, we hope to understand leadership in the community and specific forms of activity that propel leaders. The final part of this study is interviewing contributors in order to better understand the changes we find in their participation over the years –

specifically the reasons for both increases and decreases in it, their attitude toward the changes and, of particular interest, the relationship of this community and its content with their real life physical activity. The goal is thus to generate several kinds of data and understand the activity of this community more completely. Although such research has a rich history (e.g. Fields and Kafai, 2009, Harris et al, 2009), using both backend data and interviews as data sources is unusual.

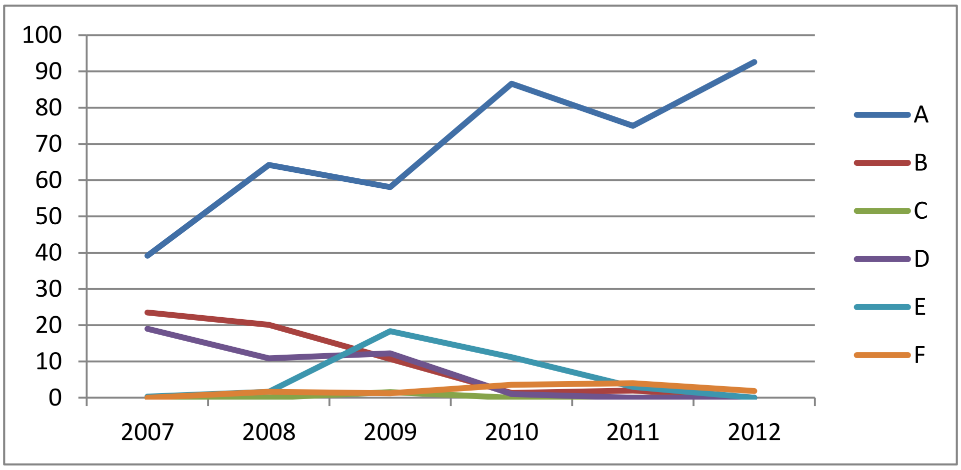

Figure 1: Member participation expressed as a percentage of posts per year between 2007 and 2012

Implications and recommendations for future research:

Given the limited degree of work done so far, we have few implications to offer. However, to the best of our knowledge, research of this scope or focus is currently not under way. There are several good reasons for initiating it:

- If the goal is to encourage participation in online communities of practice or affinity groups, then understanding patterns of activity, reasons for changes, leadership and forms of participation over long periods of time is important (Bishop, 2007).
- This is a 'naturalistic' environment that does not force/coerce or otherwise require participation, providing important insights into the life of an online community. Such insights may even be used to understand patterns of participation in MOOCs, given the freedom and self-initiated participation are their cornerstones.
- Depending upon the topic at hand, who dominates and what they say may have important implications for members' well-being. Researching participatory changes may help us monitor it better.
- Since participation makes a community, studying historical changes in the degree and kind of participation in the community will give us a more coherent picture of its life.

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Multiple Scaffolds to Promote Collective Knowledge Construction in Science Classrooms

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Abstract: In a designed-based study, we investigated the viability of knowledge communities in secondary school science classrooms using Knowledge Community and Inquiry model to guide curriculum design. Based on findings from iteration 1, scaffolds were added to the designed curriculum unit in iteration 2 to help students plan and monitor their collaborative inquiry. Findings from iteration 2 showed more science connections in co-constructed knowledge and higher amount of collaboration among students while constructing shared knowledge comparing to iteration 1.

Objective

Using the Knowledge Community and Inquiry (KCI) model, this study examined how a knowledge community approach in science classrooms could become more accessible to teachers and students by integrating collective knowledge construction in the context of relevant collaborative inquiry activities. In two design iterations, we examined how a co-designed science curriculum unit fostered the development of characteristics of knowledge communities, distributed cognitive responsibility and scientifically sound shared knowledgebase (Scardamalia, 2002), in multiple science classrooms. Curriculum topic for this study was Global Climate Change. A team of researchers, teachers, and technologist collaborated to design a ten week unit on this topic along with technological environment where curricular activities were embedded.

KCI curricula involve three interrelated phases: (A) establishing a community identity, (B) developing shared knowledge through collaborative inquiry, and (C) advancing and interconnecting shared knowledge through further collaborative inquiry (Slotta & Peters, 2008). In the first iteration of this study, students in two classes identified climate change issues of interest. Then, in cross-section groups, they conducted inquiry on the impacts of climate change on seven Canadian regions. By the end of this phase, each student picked a specialist role. In a subsequent inquiry activity, specialists from regional groups worked together to understand the implications of climate change on their domain of specialty across Canada. Students used a wiki with page templates to write their collaborative inquiry reports.

Content analysis conducted on revisions of wiki pages created in regional and specialist groups revealed that the co-designed curriculum had failed to encourage the development of distributed cognitive responsibility and the co-construction of scientifically sound knowledge. Our findings showed lack of highly integrated science content in issues pages. Also, knowledge co-construction was dominated by individuals or subgroups rather than distributed among all group members (Najafi & Slotta, 2010). Here we explain design decisions regarding incorporating reflective and regulative scaffolds in collaborative inquiry activities and report their implications in the second iteration of this study.

Study Design

In iteration 2, five Grade-9 classes participated in the study. We used a customized Drupal website to support collaboration and to represent co-constructed knowledge. In the redesigned unit, first, students from 5 classes engaged in an iterative brainstorming where first all class sections used post-it notes to add important climate change issues to chart papers that were taken from one class section to the next. The last class section reviewed existing issues, added new issues, and categorized all issues to represent important issues. Fourteen overarching categories became the topic of the first small-group collaborative inquiry. Second, small cross-section groups selected a climate change issue and collaboratively conducted a scaffolded inquiry that led to inquiry reports shared in Drupal. Finally, from the list of identified remediation plans from Collaborative inquiry 1, single-section small groups used issues pages to propose modifications to remediation plans.

We used conceptual and empirical literature on knowledge community and inquiry based learning (e.g. White & Frederiksen, 2000) to specify the desired characteristics of knowledge communities and design scaffolds to support them (Table 1). Items addressed in reflection notes fell into two broad categories: Content knowledge and metacognitive and regulative knowledge. Three reflection notes were specifically designed to promote establishing a knowledge community across classrooms, and required students to reflect on the quality of their contributions to the group, group dynamics, knowledge co-construction, scientific depth of co-constructed knowledge; and opportunities for reusing and/or improving existing knowledge base.

Data sources included all revisions of purposefully selected Drupal pages, pre-unit and post-unit questionnaires, and curriculum documents. Data analysis was conducted to: (A)Investigate distributed participation in knowledge co-construction by: (1) Contributing knowledge objects, and (2) Improving the quality of shared knowledge objects.; and (B) Examine the Scientific soundness (Linn, Lee, Tinker, Husic, & Chiu, 2006) and Epistemic complexity and growth of ideas (Hakkarainen, 2003) of shared knowledge.

Table 1: Scaffolds designed for Climate Change curriculum in iteration 2.

Scaffolds / Design Goals	Knowledge community discussion	Planning pages	Page templates	Reflection notes	Peer-review
Distributed cognitive responsibility	X	X		X	X
Deep science connections	X	X	X	X	X

Findings and Conclusion

Contents of Issues pages in iteration 2 showed more knowledge objects of partial and complex knowledge integration type compared to iteration 1. We plotted the ratio of standard deviation to mean for the number edits and the number of regulatory messages in each of the 14 Issues group. 11 groups had low to mid levels of dispersion in those measures, suggesting that group members participated in knowledge co-construction more equitably. An 80% increase in the amount of collaboratively edited knowledge-objects suggested that the co-designed curriculum for iteration 2 was successful in addressing the issue of distributed cognitive responsibility.

To further investigate the use of scaffolds, we selected two Issues groups: Deforestation group with less equitable participation among group members and Ocean Warming group, with more equitable participation among group members. Students in the Ocean Warming group used their planning page more effectively to plan for and conduct their inquiry. All but one student in this group accomplished their assigned tasks, whether the task was self-assigned or assigned by other group members. In the Deforestation group, students in each class section created a separate planning page and never merged them together. Regardless, they co-constructed content in their inquiry page spontaneously and did not use either of the planning pages.

One reflection question asked the students to comment on the scientific quality of their contributions. Using the number of words each member contributed towards factual or explanatory content, we identified students with lower quality contributions. One such student from Deforestation group wrote this reflection note: “My group-mates contributions to the issues page were better than mine because my contributions were mildly non-existent.” While this reflective note showed self-awareness of the low quality of the student’s contribution, none of the students who submitted similar answers to this question improved the quality of their contributions over time. Communicating the need for improving contributions remained implicit.

Our results suggest that with frequent epistemological treatment, such as reflective notes, it is possible to raise students’ awareness of the quality and quantity of their work even when roles and the amount of work are not micro scripted. However, to increase their effect, these scaffolds could be complemented with group-level follow ups and with in-time teacher feedback.

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Multiple effects of collaborative mobile inquiry-based learning

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Abstract: This paper presents a study on mobile learning that could be viewed as a manifestation of strong voices calling for learning in natural contexts. The study was based on a sequence of inquiry-based mobile learning activities within the domain of natural sciences and mathematics education. We questioned *the effects of collaborative scaffolding, and the effects scaffolding provided by technology have on learning and performance*. Based on a quantitative interaction analysis, findings are presented illuminating, on the one hand, the interesting potentials of mobile learning, and on the other, some serious challenges that need to be met in order to realize those potentials meaningfully. For instance, some of the findings presented shows that low-achievement students benefits from this kind of activities; that learning technologies have multiple effects on learning, both positive and negative, and that the roles of teachers is as important as before the introduction of learning technologies.

Introduction

Since the Industrial Age, and as a response to a need for mass-education, learning has, to a high extent, been considered to take place in traditional classroom environments of lectures and books. As a consequence of the mechanical spirit of the industrial era, learning traditions were developed describing knowledge not as something that can be constructed by learners in appropriate contexts, but rather as information that should be transferred from textbooks and teachers into the minds of learners (Figueiredo & Afonso, 2005).

As time has elapsed, many strong voices have emphasized the importance of natural contexts (Dewey, 1916; Lave & Wenger, 1991). In the beginning of the 20th century, one of the first authors warning about the de-contextualized nature of learning and challenging the assumption that the classroom is the optimal place for learning to occur was John Dewey (1916). He proposed the idea that "*there is an intimate and necessary relation between the processes of actual experience and education*" (p.20), advocating that meaningful learning should take place in the setting of real-world activities. Since then, several theories on learning and cognition have been introduced, such as situated learning (Lave & Wenger, 1991) and situated cognition (Brown et al., 1989), which emphasize authentic problems and natural contexts as powerful learning resources for learners' generalization process. Also, since the emergence of the mobile learning field, more and more research projects are investigating learning outside of the classroom, in the world and in authentic contexts –facilitated by mobile technology.

The step out of the classroom into more dynamical environments, combined with the increased mobility of the students and the utilization of technology, changes the conditions for providing scaffolding support. In such environments, teachers may not be as accessible due to the mobility of the students, and the dynamical contexts can constrain the possibilities for social interactions (Winters and Price, 2005). From our own experiences, we have also observed that the design of mobile learning activities and learning technologies can dramatically restrict young students' opportunities to share knowledge and scaffold each other (Nouri, 2012; Nouri et al. (2011).

Thus, in the empirical study reported on in this paper, we attempted to further question *the effects of students scaffolding each other in field activities, what scaffolding needs these situations create, and the effect collaborative scaffolding and scaffolding provided by technology have on learning and performance*. In doing that a sequence of inquiry-based learning activities were designed within the domain of natural sciences and mathematics education. The designed learning activities were aimed at a group of primary school students using mobile technology with the objective to collaboratively explore a natural phenomenon, namely the characteristics of species of plants and trees and their biotopes.

Findings

For mobile learning to become an asset to the educational system, the gap between theories of learning in contexts and practical and successful implementations must be reduced. Although some of the findings of this study, to some extent, emphasize the potentials of mobile learning, other findings have illuminated that the gap is still there with many challenges waiting to be addressed.

In regards to the potentials of mobile learning, the findings indicate that some learning certainly occurs. For instance, a 44 % mean increase in performance is not inconsiderable, although it can be gradated with the

Hawthorne effect and discussions regarding the need for control group studies and comparison to learning occurring with more traditional pedagogical models in the frame of the classroom. Obviously, one could also question what learning we assessed and how we did that in the first place, calling for richer assessments focus beyond performance scores. In terms of performances scores however, the most noteworthy finding is the impressive performance increase of otherwise low-achievement students. It seems that these students are particularly responsive to learning situations of this kind, characterized by structured activities that allowed and guided both individual and collaborative work, also providing concrete experiences of the learning material supported by the mobile technology that highlighted and captured critical features.

On the other hand, the findings also demonstrated that we, as researcher, designers, and teachers, should not rely on collaboration to unfold satisfactorily in a way that provides the students the required scaffolding. In fact, some of the findings indicate that collaborative scaffolding amongst young students can have negative impact on learning, if the students are not capable and knowledgeable enough to provide the required scaffolding. These findings emphasize two things; firstly, the still important role of teachers in these kinds of activities, and secondly, the importance of a thoughtful technology- and primarily - activity design.

After all, our analysis suggests that the mobile technology used, with all its utilized positive affordances, also gave rise to problems among students managing the technology, and to scaffolding interactions that had significant negative influence on performance scores. Bearing in mind that the technology was designed rather thoughtfully together with researchers, students and teachers, guided by usability considerations, there are reasons to believe that this issue can become more pronounced if teachers are to design or choose learning technologies on their own for educational purposes.

Our analysis also suggests that designers, whether its researchers or teachers, should thoughtfully consider how learning activities across contexts are planned for, taking account of the scaffolding needs that different tasks, learning processes, and learning contexts can give rise to. One should, for instance, not put to much focus on conceptual learning in outdoor contexts, where teachers are not as readily available, and the concerned students are believed to be incapable of providing required conceptual scaffolding to their fellow group members.

Along this line, and in terms of mobile inquiry-based learning, the goals of tasks in outdoor field activities could be limited to concretely experience the contextualized learning material, and to collect multi-modal data for further analysis in indoor environments. Essentially, designers of mobile learning activities across contexts should thoughtfully ask which learning tasks are suitable for different contexts and how learning tasks can be distributed across contexts in order to provide students with the required scaffolding for meaningful learning to occur – for as many as possible. More on this study and its findings is documented in Nouri et al. (2013).

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Towards Collaborative Argumentation in "Losing the Lake"

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Abstract: *Losing the Lake* is an educational simulation game exploring the impact of climate change on declining water levels in Lake Mead. This paper briefly describes the game and explores options for incorporating collaborative argumentation into the next iteration, including several technological options. We explain how Walton's argumentation framework is useful in generating critical questions for collaborative argumentation on many topics related to climate change and water resource management.

This paper reports on a design project, *Losing the Lake*, and efforts to incorporate collaborative argumentation into the learning environment. *Losing the Lake* is a computer-based educational resource designed to teach students about climate change and its effects on the local environment. Research suggests that many students harbor a number of misconceptions about human-induced climate change (Nussbaum, Sinatra, & Owens, 2011) due to the complexity of the phenomenon across multiple time and spatial scales, but teaching about the issue in the context of a concrete, local phenomenon aids student understanding and engagement with this issue (Moser & Diller, 2007). The phenomenon focused on in this project is the rapidly declining water levels in Lake Mead, which have been caused by an extended drought in the Rocky Mountain snowpack. This drought will be made worse by climate change.

Description of *Losing the Lake*

The educational computer system that was initially developed in this project consists of five activities designed first to explore household and community water conservation options and then the nature of climate change (and the relationship to snowpack and lake levels). The penultimate activity is for users to run a visual simulation of declining water levels (based on an actual climate model, HADCM2-A1B) and to compare their predictions of how many years each regional conservation option will delay lake levels from falling below a level where no more drinking water can be pumped from the lake.

A major design decision was not to explore climate change first because that could create fear among users, which can cause disengagement and denial (Moser & Diller, 2007). Instead, users first grapple with conservation actions they can take to build a sense of efficacy. Users start with topics that are more familiar and meaningful to them (i.e., household conservation) and then progress to exploring more complex systems.

In a study of the effectiveness of playing *Losing the Lake* as a stand-alone game among 113 seventh-grade earth science students, compared with a control group which viewed an unrelated earth science website, the game led to significantly increased knowledge gains on some topics (e.g., water conservation, the difference between weather and climate), but not others (e.g., relation of snowpack to lake levels). (Results of the study are reported in Nussbaum et al., 2012.) There was also a small increase in student interest as measured by a 10-item Likert scale instrument ($F(1, 110) = 3.98$, $p < .05$, $d = .23$), particularly in home water conservation options.

While the results are encouraging, focus group sessions with science teachers revealed that—in the next iteration of the game—it might be better to use the game over a five-day period (or longer), where each activity is played, reviewed, and analyzed by small groups of students and/or a whole class. In addition, we are in the process of incorporating argumentation activities into the game.

Integrating Collaborative Argumentation into *Losing the Lake*

Our original intent for developing *Losing the Lake* was that it could be a resource to foster student argumentation and in turn conceptual change about climate change. (Financial limitations, however, prevented the development of computer-supported argumentation features in the first iteration of the game.) Collaborative argumentation (Andriessen, 2006) involves individuals working together to construct and critique arguments, and there is evidence that, under the right conditions, it can foster conceptual change and better critical thinking (Asterhan & Schwarz, 2007; Mercer, Dawes, Wegerif, & Sams, 2004). There are a number of CSCL systems that support argumentation (see Scheuer, Loll, Pinkwart, & McLaren, 2010, for a review).

In developing *Losing the Lake,* a number of topics suitable for collaborative argumentation were identified. Some relate to natural science (e.g., Would greater and earlier melting of the snowpack increase or decrease lake levels?); some are socioscientific in nature (e.g., What are the costs and benefits of building a water desalination plant?). Some have aspects of both but primarily involve estimation and modeling (Which would save more water, covering a swimming pool or washing cars only at a car wash?).

In designing the next iteration of the game, an open question is how best to incorporate collaborative argumentation. Some options include: (1) Using only face-to-face collaborative argumentation as described above; (2) using existing chat systems that support "dialogue games," such as *InterLoc* (Ravenscroft, McAlister, & Sagar, 2007); or (3) using an argumentation mapping system, such as *Araucaria* (Reed & Rowe, 2004) that provides a list of "critical questions" for different types of arguments, known as argument schemes (see Nussbaum, 2011; Walton, 1996). For example, for an *argument from sign* scheme, one critical question is "How strong is the correlation of the sign with the event signified?" (e.g., "Is a ten-year drought strong evidence of climate change?"). For an argument from verbal classification scheme, "Is *a* really an example of category *A* or is there room for doubt?" (e.g., "Is a ten-year warming trend really an increase in *climate*?"). Such critical questions are used to evaluate arguments tied to specific argumentation schemes.

We have found Walton's argumentation framework useful because it encompasses both scientific and socioscientific/policy arguments, all of which are relevant to climate change (Nussbaum et al., 2011). Many extant computer-supported argumentation systems are either too specific, in that only one type of argumentation is scaffolded (e.g., scientific), or overly general: Scaffolds are included to promote counterargumentation or argumentation mapping without much reference to logical or epistemic criteria for evaluating arguments.

Critical questions provide such criteria. One issue, though, is how best to seed the discourse with critical questions. The next iteration of *Losing the Lake* will likely involve face-to-face argumentation and role playing activities to make the game more fun and exciting; critical questions could then be introduced into the discourse by teachers during class discussions, or by students if they are taught to ask critical questions (as in Nussbaum & Edwards, 2011). Computer-supported argumentation could be used to supplement these activities (to promote greater reflection and participation). We have found some systems such as *InterLoc* (involving locution openers) to be distracting to students and not specifically focused on critical questions. An open question is whether a structured graphing system, specifically *Araucaria*, would be useful or whether generic asynchronous discussion, with question prompts reflecting specific critical questions, would suffice.

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Collaborative Learning through Socially Shared Regulation Supported by a Robotic Agent

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Abstract: We designed a learning environment supported by a robotic agent to facilitate learners' socially shared regulation of learning (SSRL). In collaborative reading comprehension, we designed *adaptive scaffolding* scripts by the robot and its physical embodiment for helping learners' planning, monitoring, and behavioral engagement. The cognitive and conversation analyses show that the use of note-taking strategies, engagement in collaborative argumentation, and transfer of understanding were improved by the support of the robot as a *metacognitive mediator*.

Background and Research Purpose

SSRL is a regulatory process model of collaborative learning based on preceding ideas of self-regulated learning (SRL) and co-regulated learning. In Hadwin, Jäevelä, & Miller (2011), SSRL is defined as "interdependent or collectively shared regulatory processes, beliefs, and knowledge orchestrated in the service of a co-constructed or shared outcome/product" (p. 69). In SSRL, learners are collaboratively involved in planning, monitoring, evaluating, and regulating the socioemotional, cognitive, and behavioral aspects of their learning. In this study, based on the preceding research on CBLE agents (e.g., Azevedo (Ed.), 2007), we attempted to create a socially assistive robot as an agent that provides learners with *adaptive scaffoldings* of SSRL. We consider the advantage of a robotic agent over a human to be its participatory stance in collaborative learning. Learners at any age usually recognize instructors or teaching assistants as authority figures who know everything in their class. On the contrary, a robot may be accepted as an assistant or partner by learners because robots are ordinarily not considered as intelligent as learners. Learners expect that the robot will provide information that they can exploit. Therefore, learners may maintain their intentionality in regulating collaboration. In addition, robots may have an advantage of over intelligent PC-based agents. With its physical embodiment, a robot can express its engagement in learners' collaborative learning through verbal and nonverbal channels (Breazeal, 2002).

Study Description

Thirteen students including one graduate from the same departments participated in collaborative reading comprehension, an activity structure based on the Jigsaw method that enables learners to engage deeply in collaborative knowledge construction through understanding multiple document-based resources (Oshima & Oshima, 2011). Students were first divided into four *expert* groups. In each *expert* group, three students collaboratively read and constructed their understanding of a particular article that they would explain to other students who were divided into *jigsaw* groups. Through collaboration, each student produced a summary using a Microsoft Word template provided as a handout for the explanation intended for the *jigsaw* group students. Three *jigsaw* groups were then formed, each consisting of one student from each *expert* group and one robot. Students in the *jigsaw* groups worked to integrate ideas from five different articles explained by the students and robot. The robot was in charge of explaining article #3. After discussing the five articles, the students reported how ideas from the articles were related to each other and interpreted them with reference to the basic framework of learning environments in a computer-supported collaborative learning (CSCL) system. One *jigsaw* group consisted of five students, rather than four, and two students were collaboratively assigned the same article.

Adaptive Scaffolding Scripts by Robots

Based on recent studies of SSRL (e.g., Hadwin et al., 2011), we developed three types of scripts: planning, monitoring, and behavioral engagement. For planning, robot said to the learners: "I am now going to explain line (number) on page (number) to line (number) on page (number). So, please take a look at the section before I start." After completing a section of the explanation script, robot asked learners if they had questions and if there was any part that they wanted to listen to again. Then robot said: "Please tell me which part you want to discuss later. I will remember your answer and tell you [Operators took notes of learners' answers.]." After providing its explanation, robot said parts of the content that the learners had raised and encouraged them to examine their understanding by considering their relation to the concept of the learning environment. For monitoring, robot asked learners to articulate their explanations (e.g., "Can you explain that part again?" and "Well, I could not understand what you said."), to monitor their understanding (e.g., "I wonder what others think of it.") and to integrate their understanding or ideas discussed in their discourse with the concept of learning environment (e.g., "How is your idea related to others?" and "How can you explain your idea in relation to the framework of the learning environment?"). For behavioral engagement, robot encouraged specific learner's engagement in the discourse when the operators identified the learner's inactivity (e.g., "So, what do you think, (learner's name)?"). Robot's physical movement was designed for supporting its *adaptive scaffolding* scripts function. It moved its head to slowly look at everybody while it was explaining the article. Its hands moved like a human was actively talking. In addition, we prepared buttons for moving its head toward specific learners to request their utterance. For instance, when Robot asked a specific learner to engage in discourse, the corresponding script was spoken with the robot gesturing toward the learner.

Results and Discussion

First, we found that our *adaptive scaffolding* scripts for planning facilitated learners' use of note-taking strategies. They used strategies significantly more in robot explanation than in human explanation. The developed scripts provided metadiscourse for reading comprehension, and we found that learners normally did not use this type of discourse in collaborative learning.

Second, in our analysis of collaborative argumentation, our *adaptive scaffolding* scripts facilitated learners' engagement in constructing reasoning. The proportion of learners who contributed to reasoning components in argumentation was increased in the context of human explanations. The further conversation analysis suggests that *adaptive scaffolding* scripts for monitoring and behavioral engagement functioned effectively in human–human interaction, rather than in human–robot interaction. An important role of a robotic agent in such an interaction is as a *metacognitive mediator* that prompts learners' engagement through monitoring their collaborative construction of argumentation and subsequent active behavioral engagement.

Differences in the effectiveness between the contexts of learner and robot explanations might be worth examining in further research. One possible interpretation of the results is the trade-off between the roles of the robotic agent as a *metacognitive tutor* and a *metacognitive mediator*. In the context of robot explanation, learners might recognize the robot as a *metacognitive tutor* in the human–robot interaction. Therefore, robot instructions, such as planning scripts for reading comprehension, functioned quite effectively. However, scripts for monitoring and behavioral engagement might not work well to facilitate learners' SSRL, leading to collaborative construction of argumentation because the robotic agent should have known more about the target article than the other learners. Shirouzu, Miyake and Masukawa (2002), who discussed constructive interaction, stated that collaboration is productive when different persons have different roles, such as task doer versus monitor in problem solving, and when the roles are periodically interchanged. From this perspective, the context of robot explanation in the *jigsaw* group might not have been a productive situation where humans and the robotic agent could have interchanged different roles.

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Conceptual ontology framework for socio-cultural aware Computer Supported Collaborative Learning environments

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Abstract: Considering the socio-cultural contexts of learners and teachers involved in a collaborative learning activity, we provide a conceptual ontology framework for socio-cultural aware CSCL environments. This framework is composed of two ontologies communicating together and sharing the socio-cultural knowledge about the user in order to perform appropriate adaptation tasks.

Background

The purpose of this paper is to describe a new approach to adapt the CSCL environment to the learner's socio-cultural profile. In fact, adapting CSCL environments to socio-cultural characteristics of its users is a challenging task (Blanchard et al., 2010). First, it is a multidisciplinary task that needs to carry studies within humanities and social sciences (anthropology, ethnology, sociology and psychology), educational sciences and computer sciences (Human Computer Interaction (HCI), user modeling, adaptation/personalization, mediated collaboration) in order to determine and define two types of knowledge: (1) knowledge about the user which consists in socio-cultural characteristics influencing his/her behavior, personality and different states (emotional, cognitive and motivational) and (2) knowledge about the CSCL domain represented by socio-culturally sensible variables. Second, in such environment, the knowledge handled by the adaptation is very specific, semantically rich and holds various relationships among them. So to consider all these issues, we propose an ontology based models of the user characteristics (1) and the domain characteristics (2).

The proposed conceptual ontology framework

The framework is composed of two ontologies: the ontology based socio-cultural profile (SOCUDO) and the Socio-Cultural Aware CSCL Ontology (SCACO) described below.

The ontology based socio-cultural profile

The goal of this ontology is to represent socio-cultural characteristics of a user, independently of the area in which it can be used. To collect and define the concepts of this ontology as well as relations between them, we conducted a multidisciplinary study *(Ouamani et al., 2012)* in several disciplines cited above. These works studied the impacts of socio-cultural variables on humans and the necessity to take them into account in several areas. So, this ontology was built from the scratch. Once the concepts and their relationships were defined, we realized the first conceptualization of this ontology called SOCUDO

The SOCUDO concepts are describing as following: the user has a set of dimensions: he/she is characterized by two sub profiles (individual and cultural profile), lives in a social context, and has different states (emotional, cognitive and motivational state). He/she also belongs to an age class which is an important concept here because the dimensions mentioned above vary across age. Each dimension is composed of a set of characteristics.

The socio-cultural aware CSCL ontology

This ontology is designed to represent computer supported learning collaborative variables, influenced by the socio-cultural characteristics of the user represented by the first ontology. To build this ontology SCACO we have applied the same construction process of SOCUDO. Subsequently, we tried to compare our ontology with existing ontologies representing the same domain subject, trying to find similarities or a possibility of extension. We have found that the more appropriate one is the CSCL ontology (Barros et al, 2001).

The communication and the sharing of socio-cultural knowledge between the two ontologies:

The two ontologies are closely related. They communicate to share socio-cultural knowledge about the user in order to trigger the appropriate adaptation tasks. The SOCUDO ontology is instantiated for one user after his/her information inputs via the forms; this instance of SOCUDO triggers an instance of SCACO (see Figure 1) for this user based on adaptation rules (example: If PowerDistane= hierachical and belonging= collective then assistanceDegree= high show wizard). Then, the adaptation process will use this instance to trigger the right adaptations tasks for this user.

The figure 1 shows an example of an instantiation part of the two ontologies based on some adaptation rules. The user "Sarah Ben Foulen" is from Tunisia and live in Tunisia then he has a cultural profile characterized by a “collectivism” belonging, “Hierarchic” power distance, “monochromic” time attitude, “dominance” relationship with environment and “Uncomfortable” risk and uncertainty avoidance. These concepts values trigger specific concept values in the second ontology: For example “Hierarchic” power distance triggers a “pushy” assistance manner, “teacher” help initiator, “formal/structured” activity structure, “hierarchical” control type, etc.

Discussion and conclusion

This poster presentation outlines an ontology based modeling approach that aims to give a common vocabulary used to model user socio-cultural characteristics and to show how these characteristics impact the collaborative learning settings and outcomes. The knowledge modeled using ontologies as well as the adaptation rules were extracted and defined from a considerable multidisciplinary literature study effort.

This research has several practical and theoretical implications (1) concerning its significance for theory development, the study contribute to previous attempt to understand the socio-cultural impacts on user (behavior, communication, cognition) by trying to gather, unravel and model all the socio-cultural influences on human beings and its impacts on collaborative learning. (2) Concerning its significance for educational practices, the adaptation of CSCL systems to the socio-cultural characteristics of the learners may enhance the learners’ satisfaction with the collaborative learning tools and in an intercultural collaboration, the system will be able to resolve cultural conflicts and make the intercultural collaborative experience more effective. (3) Concerning its significance for design and development practices, the use of ontologies may enhance the sharing, the usability, the structuring of the knowledge handled by the system, the interoperability of ontology based model and the reasoning about knowledge.

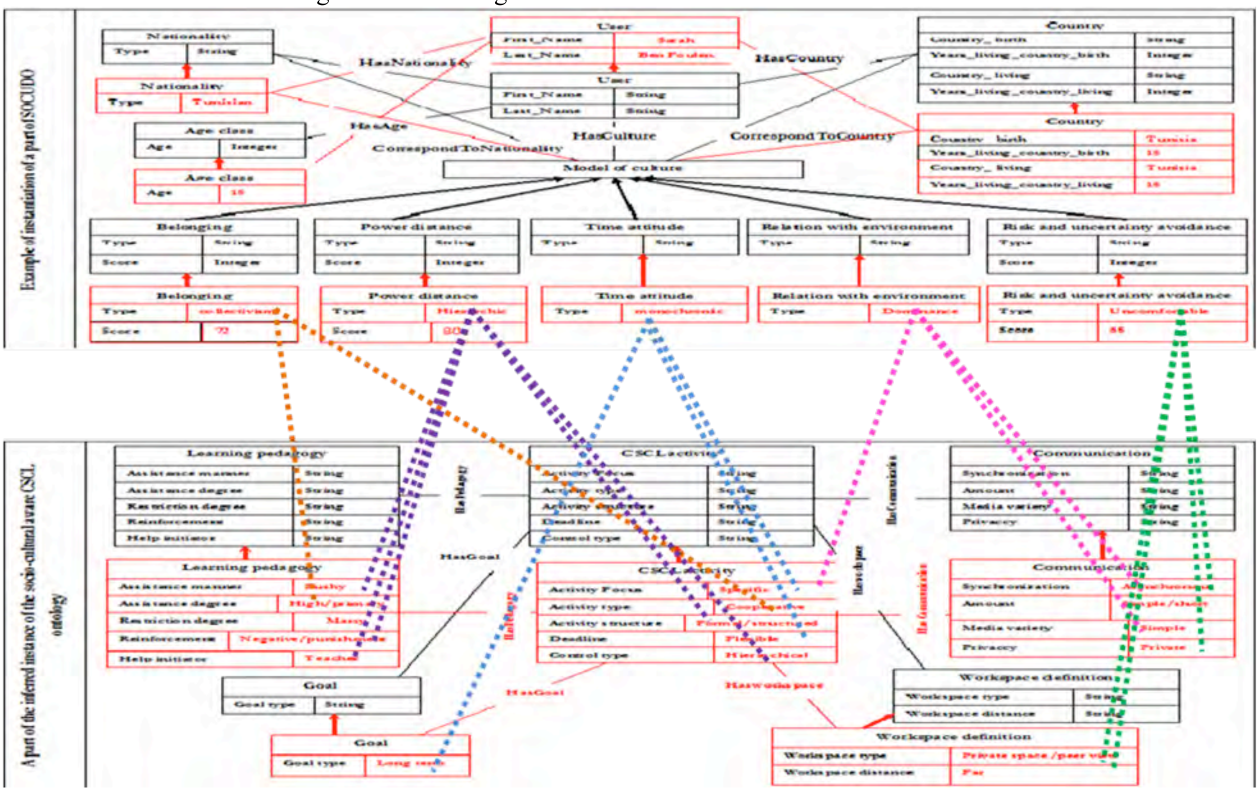

Figure 1. Excerpt of an example of instantiation of SOCUDO and SCACO ontologies and their relationships

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Understanding the enactment of principle-based designs: Conceptualizing principle-based approaches as carriers of principles for learning

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Abstract: Using a metaphor of pharmacological carriers, we will present how teachers in a Singaporean primary school enacted the Knowledge Building Communities model (KBC model) as a new principle-based approach. Ideas First project was implemented in a Singaporean primary school and it has visible outward features such as the practices and structures that are external embodiments of the design principles. This study aims at advancing an understanding of the enacting of new educational models.

Introduction

The Knowledge Building Communities model (KBC model) and its associated technology-based learning environment, Knowledge Forum, have been drawn attention in the field of CSCL for over 20 years (Bereiter, 2002; Scardamalia, 2002; Scardamalia & Bereiter, 1993, 2006). Although exemplars of the KBC model exist in various parts of the world, a better understanding is needed of how to bring the model to life in classrooms (Bielaczyc, Kapur, & Collins, 2011; Chan, 2011). Ideas First is a two-year science program co-designed with primary school teachers that has been operating in P3 and P4 classrooms in a Singaporean primary school since 2006 (Bielaczyc & Ow, 2007, 2010). The program is based on the vision of a KBC model where students work to advance the science understanding of the classroom community through engaging in collectively building knowledge in response to problems of understanding (Scardamalia & Bereiter, 2006). Students are supported in their work by Knowledge Forum, that allows learners to construct a communal multimedia knowledge base that visually traces the community inquiry (Scardamalia, 2004). One concern in the enactment of the KBC model is that of "lethal mutations" that undermines its principles and goals (Brown & Campione, 1996). What are the design features of Ideas First that set P3 and P4 classrooms on implementation paths (Bielaczyc & Collins, 2006) with fidelity to principles of the KBC model? We utilize the metaphor of pharmaceutical carriers to better understand the enactment of a KBC model in classrooms. Our goal in the poster presentation is to provide insights into design features gleaned using the metaphor of pharmacological carriers that support the enactment of principle-based designs with fidelity to the underpinning principles and goals.

Understanding Teachers' Enactment of Ideas First

A metaphor of pharmacological carriers can be used to understand the enactment of principle-based approaches. Carriers are used in pharmaceutical science for the delivery of genetic material or medicine to the therapeutic sites of action. Pharmacological carriers take on a form that results in the encapsulation of material for delivery to the sites of action. Pharmaceutical carriers have characteristics that determine their efficacy. Some of these include, the body's recognition of carriers as foreign entities, the ability of the carrier to exist in prolonged circulation and the stability of the carrier.

Ideas First project has visible outward features such as the practices and structures that are external embodiments of the design principles. The external features of principle-based approaches are analogous to the external capsule of pharmacological carriers, while the principles of the principle-based approaches are analogous to the genetic material and therapeutic drug within the carriers. Similar to pharmaceutical carriers, these outward features facilitate the delivery or take up of the principles in the classroom. When the classroom community takes up the principles, the classroom culture shifts reflecting the different principles and educational goals of the approach. This is analogous to the effect when genetic material and therapeutic drugs achieve their therapeutic effects. We draw on our research on Ideas First project to illustrate teachers' implementation of KBC model the characteristics of pharmacological carriers to understand teachers' enactment of principle-based approaches:

- ***The foreign nature of principle-based approaches:*** Carriers are foreign entities introduced into the body. Likewise principle-based approaches are designed with different visions of learning compared to existing approaches in classrooms. The introduction of these approaches and their novel practices and structures are thus akin to the introduction of a foreign entity into the human body. As the class community will mount a defense against the foreign approach, the introduction of Ideas First may result in reactions to the new approach that includes the adoption of strategies without understanding of the deeper principles as well as the appropriation of strategies and structures into existing practices. Initially, the reactions can appear as mutations of the enactment of designs. However to avoid ongoing mutations to the extent that they become lethal mutations, we have developed a realization of importance of designing practices and structures that lend themselves to long term use by the classroom community.

- ***The ability of principle-based approaches to have a "prolonged circulation" in the community:*** An important characteristic of carriers that increase their efficacy is their ability to prolong their circulation in the organism. In *Ideas First*, the tri-phasic design of the approach based on KBC principles enabled the repeated enactment of practices and structures. The constant enactment of the principle-based practices and structures provided multiple opportunities that reflected an emerging understanding of the principles.
- ***The stability of the practices and structures of the principle-based approach:*** Another important characteristic of carriers affecting their efficacy is the stability of the external capsule. This allows the carriers to achieve prolong circulation and reach their target areas. Likewise, it is important to design structures and supporting artifacts for principle-based approaches to establish stable learning environment for teachers and students in classroom. In *Ideas First,* artifacts such as the Think Cards (Ow & Bielaczyc, 2007) and hypothetical game configurations (Bielaczyc & Kapur, 2010) lend stability to the practices by making visible knowledge building practices and support the reflection, learning and enactment of practices consistent with the design principles.

Significance

This poster presentation contributes to advancing an understanding of the enacting of new educational models, especially how the participating teachers perceive and implement KBC model as a new principle-based approach and how their perceptions and implementations have changed over time.

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Using Mobile Technology to Support Innovation Education

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Abstract: Innovation is critical to our prosperity. A vital task in innovation is to understand the context within which problems occur. This poster investigates the potential of mobile technology and location-based learning to help novice innovators identify unmet needs using human-centered design research techniques. Drawing on an authentic situated learning perspective, we describe a place-based investigation activity supported by mobile technology.

Introduction

Serial innovators aiming to make meaningful improvements to our daily lives are driven to identify and understand complex problems. Without understanding the context of problems through research techniques such as field observations, addressing authentic needs is limited to the innovators' speculation and assumption. Unfortunately, opportunities to practice researching real-world problems are limited for undergraduate students. To prepare students for careers in innovation, we need to explicitly teach them how to identify and understand problems from the perspective of those who are most affected. Developments in place-based learning initiatives (e.g. Squire, 2009) suggest an opportunity to create meaningful learning experiences outside the classroom and spread the learning experience throughout the community. We describe an activity facilitated by mobile technology to help novice innovators develop the specific skills necessary to understand the users' experience.

Background

Innovation is the intentional implementation of novel and useful processes, products, or services designed to benefit society applied to a new domain (West & Farr, 1990). A critical aspect of successful innovation is a project's response to a genuine human need. Professionals conduct detailed and systematic observations of a target situation and user to gain the understanding necessary to discover opportunities to innovate (e.g. Beyer & Holtzblatt, 1997). Traditional undergraduate design research curriculum is often offered as a course module, informed by textbook readings and direct instruction in a classroom setting, sending students out into the field to practice the skill alone (Fixon, 2009). These activities lack specific guidance regarding process, reflection and feedback at the actual point of observing user behavior.

Research Method

The goal of this work is to distill design principles for teaching research methods to undergraduates undertaking innovation education. Here we describe the initial design cycle of a design-based research study (Design-Based Research Collaborative, 2003) which utilizes multiple iterative rounds of design and testing to improve an intervention's impact while developing a deeper theoretical understanding of the learning occurring. Our central research questions are to understand how novices conceptualize the process of understanding users and how location-based activities situate the learning of design research decision-making. We applied human centered design research methods (Easterday, et al., in press) including ethnographic observation, interview and cognitive task analysis to investigate common struggles when conducting field observations, compare expert and novice needs finding strategies, and reveal possible opportunities for an educational intervention.

Initial Findings

In an ethnographic study of 22 undergraduates learning to be innovators, we found that existing instruction in understanding users was not sufficiently preparing them for the task of needs finding. The novices represented a variety of academic majors and worked on project teams of 4-6 people. An artifact analysis indicated that many learners' field observation data sets lacked objectivity, clarity and depth. Furthermore we discovered that novices often observed alone, comparing their findings with their group members only later after leaving the field, forgetting key information and missing opportunities to learn from other investigators while still on site. Without clear, immediate feedback, many novices judged their efforts adequate and expressed desire to move 'forward' into a new phase of design, reflecting their conception of a linear design process (Lande & Leifer, 2010), unlike professionals who perform reflective, collaborative, on-site analysis to drive further investigation.

Design Rationale

We aim to give students authentic opportunities to practice observing behavior *in situ*, foster reflective dialogue about the observation process, separate their subjective interpretation from observable data and make decisions when following promising leads. We support location-based learning with the ARIS augmented reality system (http://arisgames.org), which allows us to cultivate a customized digital map with messages that are triggered by proximity according to the learners' GPS coordinates (Fig. 1). Following an orientation session facilitated by an experienced local innovator, we invite small groups of 3 to 5 students to investigate phenomena at various locations throughout the community. Students use handheld mobile devices to track their position within the map space and discover challenges requiring them to observe specific behavior or conduct a group reflection on an aspect of the process (Fig. 2). The system facilitates note and photo taking, tagged with GPS data, which students refer to when they return for a data synthesis and large group debrief phase.

The situated activity structure is developed from an understanding that knowledge is constructed through exposure to and interpretation of new phenomena, and that this process is directly influenced by the context in which the learning occurs (Lave & Wenger, 1991). According to expert innovators we interviewed, the knowledge gained from investigating complex situational behavior should not be limited to the subjective interpretation of a single individual, but instead compared with others working on the same task. This aligns with Roschelle and Teasley (1995) who describe collaboration as a negotiation between individuals resulting in the construction of shared meaning and conception of a problem. Therefore when teams debrief after an observation session they are not only clarifying what they saw as individuals but the group builds knowledge that forms the basis for the team's future reference and decision making (Stahl, 2006).


Figs 1 & 2. ARIS map and sample challenge interface

Future Work

Using mobile technology and computer supported collaborative learning principles we are extending traditional innovation education into the field where learners have struggled. Early tests suggest this activity is engaging and interesting for novices, and helps guide meaningful conversation. The next steps on our research agenda include further evaluation of the learner's experience, testing additional elements of gameplay, and developing a structure for user contribution of observation challenges. This project will be an asset to the Learning Sciences because it will help inform the design of mobile place-based learning activities and identify principles for helping novice innovators as they develop skills to understand the context of user experience.

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Can we increase students' motivation to learn science by means of Web-based Collaborative Inquiry?

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Abstract: This study hypothesized that web-based collaborative inquiry in science classrooms can be considered as a need-supportive environment which in turn can foster good quality motivation as conceptualized by the Self-Determination Theory (SDT). The results did not confirm the hypothesis of an increased autonomous motivation, however an increase of controlled motivation was found. We discuss how we can improve the teaching and learning environment to satisfy students' basic needs and improve good quality motivation.

Theoretical background

Many countries are facing a decline in motivation for science resulting in reduced numbers of young people choosing to pursue the study of science and a career in science. This finding has been one of the driving forces for developing and implementing computer-supported collaborative learning environments. CSCL environments are often perceived as motivating learning environments since students are connected to their peers and to technology they regularly employ for informal learning. However, to date the focus is more on theories of learning in CSCL settings whereas motivational analyses are still rare (Dillenbourg, Järvelä, & Fisher, 2009). Though, we need this kind of research to specify the exact motivational challenges of CSCL. To meet this gap, this paper focuses on the implementation of a web-based collaborative inquiry project in secondary science education and unravels if it can contribute to the aim of fostering students' motivation to learn science.

Motivation from a Self-Determination perspective

According to Deci and Ryan's SDT (1985) , motivation can be distributed along a continuum from low to high levels of self-determination. The most self-determined style of motivation is intrinsic motivation. In addition, several types of extrinsic motivation have been proposed each with a different degree of self-determination. From a high to a low degree of self-determination, there is identified regulation where the individual's behaviour reflects conscious values and is internalized as personally important; introjected regulation which represents a partial internalization without completely accepting it as one's own; and external regulation which takes place when a behaviour is performed for external rewards or constraints (Deci, Vallerand, Pelletier, & Ryan, 1991). The subcomponents intrinsic motivation and internalized extrinsic motivation on the one hand refer to *autonomous motivation*; external and introjected regulation on the other hand refer to *controlled motivation* (Vansteenkiste et al., 2009). Previous research within the SDT tradition has shown that an autonomous, relative to a controlled, regulation of study activities is associated with various positive learning outcomes (see Reeve, Deci, & Ryan, 2004, for an overview). Moreover, regarding science education more particularly, it has been found that the more self-determined students' science motivation, the more likely they should consider an education and a career within a scientific field (Lavigne, Vallerand, & Miquelon, 2007). In this respect, autonomous motivation need to be fostered.

Basic Need Satisfaction and Web-based Collaborative Inquiry

Within the framework of SDT it is maintained that teachers foster autonomous motivation when they create an environment that facilitates the satisfaction of three basic needs: 1) students' need for autonomy, 2) competence, and 3) relatedness (Vansteenkiste et al., 2009). First, teacher autonomy support involves the offering of choice, the minimization of controlling language, and the provision of a meaningful rationale. Second, the need of feeling competent can be supported by the provision of structure, including optimal challenging tasks, praise, encouragement after failure, and adequate help. Finally, to meet the third basic need of relatedness the provision of involvement is important which refers to the experience of a sense of closeness and friendship with one's student peers. This study put forth Web-based Collaborative Inquiry by means of the online learning environment WISE (Web-based Inquiry Science Environment, (Slotta & Linn, 2009) and hypothesize that implementing web-based collaborative inquiry in science classrooms can be considered as a need-supportive environment which in turn will foster autonomous motivation for science learning.

Methodology

The participants in this study were 220 students from 13 secondary school classes (grade 9 and 10). The average age of these students was 16 years. The ratio of males to females among the participants was 63% boys to 37% girls. The science teachers of these classes were asked to dedicate four class periods of 50 minutes to complete the intervention, i.e. the implementation of a web-based collaborative inquiry curriculum project. Students' motivation for science learning was measured by means of an adapted version of the Academic Self-Regulation Questionnaire originally developed by Ryan and Connell (1989), yet redesigned by Vansteenkiste, et al. (2009). This 16-item scale containing four items per regulation type has been successfully used and validated in the context of previous motivation research. In this study, the questionnaire has been conducted during a pretest and posttest to assess potential shifts in the quality of motivation. Internal consistencies for the eight-item subscales, as indexed by Cronbach's alpha, were satisfactory for both *autonomous motivation* (pretest $\alpha = .93$, posttest $\alpha = .94$) and *controlled motivation* (pretest $\alpha = .72$, posttest $\alpha = .85$).

Results & Discussion

Based on the results of this study, the hypothesis of an overall increased good quality motivation for science as a result of being exposed to web-based inquiry during secondary science education need to be rejected since no significant pre to posttest difference is found for *autonomous motivation* ($t = .04$, $df = 211$, $p = .97$). On the other hand an overall significant increase of *controlled motivation* is found ($t = -2.21$, $df = 211$, $p = .03$), but this does not result in more qualitative motivation profiles.

We need to conclude that higher learner motivation, which in this study meant more qualitative motivation, cannot taken for granted because of an innovative learning approach. This finding can be related with what Dillenbourg et al. (2009) described as 'the myth of media effectiveness'. This refers to the fact that entering new media in the educational sphere often generates over-expectations with respect to its intrinsic effects on learning. This finding force us to rethink the implementation of web-based collaborative inquiry in science education in light of the satisfaction of the three basic needs. Regarding autonomy support, we need to think about how we can provide students with more choice, for example with regard to the completion of inquiry activities. Regarding competence support, although it is found that most students don't have operational problems during computer-assisted learning, a lot of students struggle during information problem solving on the web (cf. the myth of the digital natives). Next to scaffolding for domain-specific knowledge, also scaffolding the metacognitive skills during CSCL need to be stressed. Regarding relatedness finally, as noticed by Blumenfeld et al. (2006), students need to adjust to a new relationship with the teacher who becomes a facilitator rather than the primary source of information, but also teachers need to adjust to a changing role which in recent years has become central concern in CSCL (Dillenbourg et al., 2009). In addition, although students are working together in small groups at the computer, this does not guarantee that they engage in collaborative knowledge construction and in shared regulation. The question how we can improve the probability that students communicate with each other, seek feedback from each other and jointly approach the learning activity and negotiate solutions to complex problems is also one of the challenges in CSCL research.

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Design in the world AND our work

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Abstract: Design is a ubiquitous term in CSCL and the Learning Sciences, but neither discusses design methods in parallel to how design is represented in classical design fields. We examine the use of the word "design" in publications. On-going analysis explores published representations of design process at a finer grain size. We tentatively find a lack of *problem finding,* a scarcity of iterative design, and notions of customer needs in contexts are largely absent.

Issues Addressed and Potential Significance

Design as a term has been a significant part of the CSCL discourse since the first issue of ijCSCL (Volume 1 No 1 2006) with 308 references spread across 7 articles. This focus builds on the use of the term in issues of the Journal of the Learning Sciences (e.g. an early CSCL focused JLS issue - Volume 3 No 3 with 77 references across 4 articles). However, myriad forces conspire to distract us from taking design seriously; chief among these are notions that generalizability and scalability are the dominant goals of our work. These selective pressures lead us to seek overt and covert means to teacher-proof our designs for learning and to decontextualize our findings. Rather than presenting our design decisions in tandem with findings and descriptions of context, we tend toward abstraction, inferring design principles, which in practice may be applied haphazardly or incoherently. We note three ways to consider how we may or may not act as designers: design involves problem finding; design problems emerge from customer needs and/or user experiences; and that problems and solutions co-evolve as design work progresses.

Notions of *design* and in particular *design thinking* have gotten a foothold in the adjacent community of The Learning Sciences and beyond; for instance, in a recent *Review of Educational Research,* it is claimed that design thinking "can also have a positive influence on 21st century education across disciplines because it involves creative thinking in generating solutions for problems" (Razzouk & Shute, 2012, p. 331). Design thinking is valued by our communities as a means for solving "wicked problems" (Rittel & Webber, 1984). However, there is concern voiced from design fields regarding this infiltration of design thinking, in part because "an identification of design with problem solving and with strategies for change paints but half the picture" (Stewart, 2011, p. 516). One of the ways in which design problems differ from other types of problems, is that they tend to be ill-defined (Cross, 1982). A way to illustrate this is to consider how the design problem as given differs from the problem as solved, meaning that when the same design problem is assigned to fifty teams, there will not be "'fifty solutions to the same problem' but, in important respects, 'fifty different solutions to fifty different problems'" (Harfield, 2007, p. 160). In this way, design problems and solutions are seen to coevolve (Dorst & Cross, 2001). Embedded in concerns about design thinking is the notion that design is simply problem solving; however, design from the design thinking perspective begins from *problem finding* activities undertaken by designers, who value the "need for more informed insight into user experience, especially in the context of rapidly developing digital technologies," (Stewart, 2011, p. 516). We wondered, to what extent are our designs – be they designs for learning, software or research-- explicitly emergent from customer or user needs? To what extent are the problems being viewed as ill-defined? And finally do the solutions and problems co-evolve as the design work progresses. "Scholars do not usually ask: Who does the design benefit and why? This linear view is associated with notions of perfection, completeness, and finality" (Engeström, 2011, p. 600). Research questions focus on how the use of the word "design" has changed in the adjacent communities of CSCL and The Learning Sciences. In particular, we consider passive uses of the word design ("the activity was designed to engage") and contrast these with more designerly (Cross, 1982) uses in relation to the journal, year, and topic. Further, we explore antecedents of design experiments and design-based research to better understand the myriad ways design --as a process-- is viewed in these communities of scholars. Ultimately our goal is to examine our layered uses of the term design and through this analysis to better understand it in terms of meanings and processes that exist outside of the CSCL community. By providing a better understanding of our various uses of the term design we anticipate the CSCL community may be able to consider where design and in particular design thinking could lead us in terms of our work.

Connection to Conference Theme

Our poster addresses the conference theme: "To see the world AND a grain of sand" by examining how design, as it has been used by the CSCL community, has become laden through the layered ways we have engaged in talking about it. When we zoom out-- *seeing the world*—the work in CSCL and The Learning Sciences appears to align with design; However, when we zoom in—*seeing the grain of sand*—references to design work diverge, with some researchers enacting strong design processes, and others omitting much of what being designerly is about. Ultimately, we contend that design is not simply problem solving; it involves locating needs in the world, understanding them within contexts, working between the problem and solution towards a suitable solution. Our preliminary work in this area provides a beginning point for a renewed discussion about the nature of design as it has been presented in iJCSCL and how these descriptions relate to the designerly ways that have been part of the discourse in the allied design fields.

Methodological Approach

We began our review by searching three journals: *Journal of the Learning Sciences* (JLS, 1991-2011), *International Journal of Computer Supported Collaborative Learning* (iJCSCL 2006-2011), and *Design Studies* (DS 1991-2011) for the word "design." We created a database of all sentences containing the word design, omitting only those that were contained within transcripts or in the references cited (e.g., a journal title). We then began an on-going analysis of uses of the word design (e.g., "X was designed to…" see Figure 1).

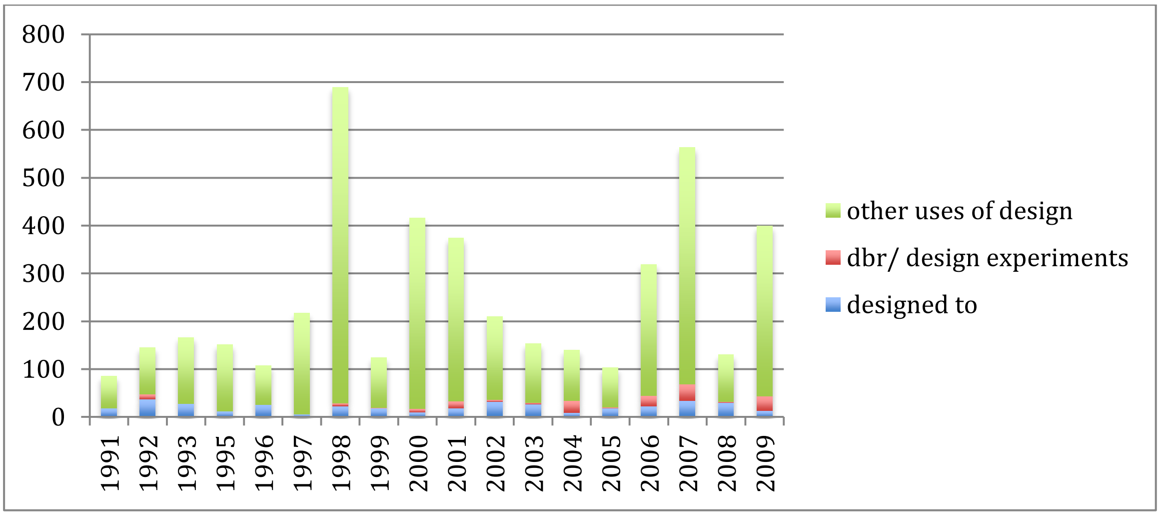

Figure 1. Uses of the word "design" in *The Journal of the Learning Sciences*

Major Findings, Conclusions and Implications

First, we infer that our current analysis continues to be incomplete, and has not been conducted at the right grain size. We conclude with next steps for our on-going analysis. First we plan to examine articles at a finer grain size, and with a particular focus on the relationship between iJCSCL and JLS; we posit that the 2006 introduction of iJCSCL may have impacted how design is presented in JLS. This issue is a current concern for these adjacent communities; for instance at the 2012 *International Conference of the Learning Sciences* (ICLS), an "open meeting of the CSCL community at ICLS" was held, and some attendees voiced concerns over their continued presence at ICLS. We wonder what might be lost – in terms of design capacity-- if these two communities were to further diverge. Disappointed by not having those features- what opportunities are missed by not having certain aspects of design in our process. In particular, we fear the *lore* of design as a fairly straightforward, linear process of problem solving will continue to dominate. Our communities are not talking about design in the ways reflected in journals such as *Design Studies*. There is a lack of visible iteration, and sparse reference to users or customers (perhaps because we find these terms abhorrent), but our initial analysis has yet to reveal a strong parallel for this role. We anticipate constructive discussions at CSCL 2013.

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Interview Findings on Middle Schoolers' Collaboration in Self-Organizing Game Design Teams

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Abstract: Understanding how younger students can learn to collaborate, and affordances of the learning environment that can effectively support this, are critical questions for knowledge sharing, networking and innovation in education. Exploratory research results on emergent middle schooler collaborative activity in a guided discovery-based learning program are reported. Students in self-organizing game design teams experience certain challenges (e.g., version control), and innovate solutions. Some indicate meta-knowledge development and socialization gains. We conclude with ongoing questions.

"Guided discovery-based" learning experiences are those in which learners are given a particular task (e.g., a problem or a project) that must be supported by inquiry. That is, in order to successfully complete a task, the learner must develop core disciplinary knowledge as well as practices (e.g., the technical means of creating a multimedia project). Discovery denotes the need for student engagement in autonomous inquiry to support development of the core knowledge and expertise in the practices, to complete the given problem or project task. Often such complex activity is completed in teams. One example of this type of intervention is the Globaloria program, which embodies the principles of Constructionism and distributed cognition (Harel & Papert, 1991; Salomon, 1997), and is being implemented in middle and high schools in several U.S. states. Participating students engage in collaborative game design within a formal, in-school class. The primary goal from the students' perspective is successful completion and online publishing of a functioning web game, which they also enter into an annual competition. To complete a game, students participate in several integrated technology-supported activities to meet a range of instructional objectives (Reynolds & Harel, 2009). The instruction involves two less-structured areas that are largely self-organized by students: (1) resource use of a wiki-based information system containing the curriculum, online syllabus, sequence of assignments, and tutorials on game design and Flash programming, and (2) student collaboration in teams. An exploratory study was conducted to investigate students' collaborative engagement in co-located game design, as supported by the wiki environment and a studio-based classroom setting in which knowledge-sharing as a value was made explicit by teachers (Salomon, 1997). Here we discuss middle schoolers' collaborative activity that emerges when given the chance to self-organize their game design teamwork.

Methods

Intervention. In brief, Globaloria provided digital learning supports via a wiki-based social media platform, twice- teacher training, and ongoing webinars with students and teachers. In-school classes followed a blended learning curriculum daily, for up to 90 minutes per session, across either a semester or a full year. Within this curriculum, students first engaged in individual game design across 3 modules. Educators were minimally trained on supporting collaboration and teamwork processes. Students chose their own teams and largely self-organized, delegating tasks and roles. The wiki featured an informational text page text outlining team roles.

Data collection and analysis. We visited four schools in two states and interviewed 18 teams of participating Globaloria students and their teachers at two timeframes (March and May of 2012), asking about their experiences with collaboration, teamwork, and resource use. We recorded all interviews, adopting a grounded theory analysis approach to the dataset, and engaged in several rounds of coding video.

Results

Role-taking and division of labor. Teams self-reported variation in strategies for self-organization, role-taking and division of labor. For instance, some students (especially 6th-graders working in pairs) worked collaboratively on shared tasks on a single computer at times, involving negotiation and decision-making for small incremental steps in the task, such as the color of a background, or figuring out the coding of buttons. Other teams reported delegating tasks, with individuals working separately and in parallel, coordinating only when deemed necessary. We found that in most teams, individuals took on varying roles they preferred (e.g., programmer, graphic designer, researcher), occasionally shifting roles. Some reported self-monitoring and evaluation of teamwork processes, and distributed expertise held by individuals at varying levels of mastery (Barron, 2003). Some teams strategically organized roles to leverage perceived strengths of individuals therein. Most teams reported some difficulties self-organizing, negotiating tasks and cooperating. Many discussed particular instances when communication broke down; several also reported pride in coming to some agreement.

Peer Help. A culture of informal peer teaching appeared to take hold in the game design classrooms. Many students reported their teachers had established a prescribed set of problem-solving steps for students to follow in seeking help: first they must visit the wiki to find answers, then ask a team member or peer in the class, and finally, the last resort is to ask the teacher for help. Certain students became recognized for their acumen in specialized areas such as programming, and were sought out by other peers in class for specific help. Teachers informed us that some of these game design leaders were under-performers in traditional school, and upon participating in this class, had made clear gains in knowledge, social standing, and self esteem. Student experts we interviewed appeared to enjoy this new role, and the value proffered by the community upon their expertise. Other students also reported gaining expertise and learning through their interactions with the expert peers.

Version Control. One challenge students faced was keeping track of game file versions. Because of variation in self-organizing teamwork processes, students required varying strategies for merging distributed work and project files. Version control issues appeared to have challenged some groups' productivity. Adobe Flash source files do not lend themselves easily to version control. Although some more advanced students reported fluency in importing work of others into a central Flash project file, such as graphics or code from other team members' files, several teams indicated confusion over this. Many reported an intention to tackle integration at the end, saving and accruing distributed work individually in files on local computer hard drives. Although the wiki was meant to help students project manage file version control, most teams noted that the wiki served as an occasional backup archive, rather than the main channel of file transfer and coordination. Teams reported using flash drives to transfer shared files, which occasionally became lost. Some teams emailed each other files. Attempting to control for the complexity of managing many different tasks, a few teams reported dedicating use of a particular computer for a particular function (e.g., "the computer on the left is where we save graphics files, and the one on the right is for coding"). Such a strategy may reveal that some students struggled to conceptualize parallel multi-tasking capabilities such as multiple file tabs in Flash project files, SWF files, folders, and file management in general. Similarly, some students reported sharing their login credentials for the wiki with each other, enabling a given individual to log into another's account and upload his/her files into the other's file gallery as one mode of transfer (when they could simply login and upload as themselves to make files accessible to all classmates on the wiki). As deadlines approached, teachers reported stepping in to scaffold and help students integrate files.

Discussion

Findings indicate that applying the instructional design decision to allow middle-schoolers to self-organize teamwork in guided discovery-based learning appears to both afford and constrain student collaboration and distributed cognition. By following an intensive collaborative design experience, some students develop insights about collaborative work processes (Barron, 2003). Students' reporting of delegation of team roles based on perceived expertise shows evidence of consciousness and meta-knowledge about roles. Comments made by some students about being sensitive to team members' feelings while delegating based on perceived expertise also reflects a certain socialization and cooperation. Although some students had difficulty with version control and file management, others seemed to develop adaptive strategies such as use of Flash drives, ultimately learning how to copy/paste features and code created by others into a central project file. It appears that version control and task delegation could be structured more by teachers and/or the curriculum and e-learning system, to facilitate greater productivity. Also, while benefits exist to allowing students to specialize in and master certain tasks (e.g., graphic design; programming; online research), if the program aims to cultivate common skills among all students in all areas, a more structured approach to role-taking must be considered to ensure students have adequate experience with practices and time on task for learning. These results lead to questions about ways in which the social tools could better support distributed expertise. Another question relates to how teachers might capitalize on emergent roles (e.g., Hmelo-Silver et al., 2007; Miller et al; 2013) while at the same time finding ways to assign roles that are important but don't emerge. Ultimately, we observe that tensions exist among: (a) the constructionist framework used in the guided discovery-based program investigated, (b) its goal to facilitate student-centered learning, (c) the need for collaborative teamwork to be productive, and, (d) formative/summative assessment constraints imposed by schools that assume common outcomes for all, that warrant further consideration and investigation. These questions have key implications for the design and implementation of computer-supported collaborative inquiry-, discovery- and project-based learning in schools.

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Digital Evidence and Scaffolds in a Model-Based Inquiry Curriculum for Middle School Science

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Abstract: The Framework for Science Education (National Research Council, 2011) and the subsequent Next Generation Science Standards feature modeling as an integral component of inquiry driven classrooms. Evaluating such models entails careful consideration of fit with evidence. In this poster we discuss student use of computer animations, simulations, blogs and emails as sources of evidence in a collaborative model-based inquiry middle school science curriculum.

In this poster we present a method of using computer animations and other digitally generated and presented material in the context of a model-based inquiry curriculum used in a middle school science classroom. Model-based inquiry entails a shift away from narrower conceptions of science as hypothesis generation and testing to a view of science as a set of practices for generating scientific explanations and theories in a setting of critical discourse (Windschitl, Thompson, & Braaten, 2008). Recent developments in national science standards reflect this view; "The focus here is on important practices, such as modeling, developing explanations, and engaging in critique and evaluation (argumentation), that have too often been underemphasized in the context of science education." (NRC, 2012, p. 3-2). Our conception of inquiry-based modeling includes the use of a rich set of evidence that students collaboratively assess in small groups and use to support or rule out competing models.

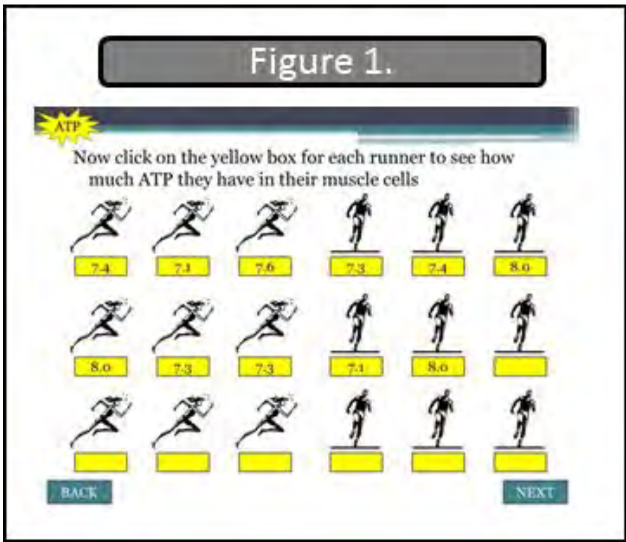
Our study was conducted with over five hundred students in more than twenty science classrooms. A typical lesson included two or more scientific models that students evaluated in light of three to six pieces of evidence. Students reflected on the quality of each piece of evidence and how it related to each model, by supporting the model, contradicting the model, or being irrelevant to the model.

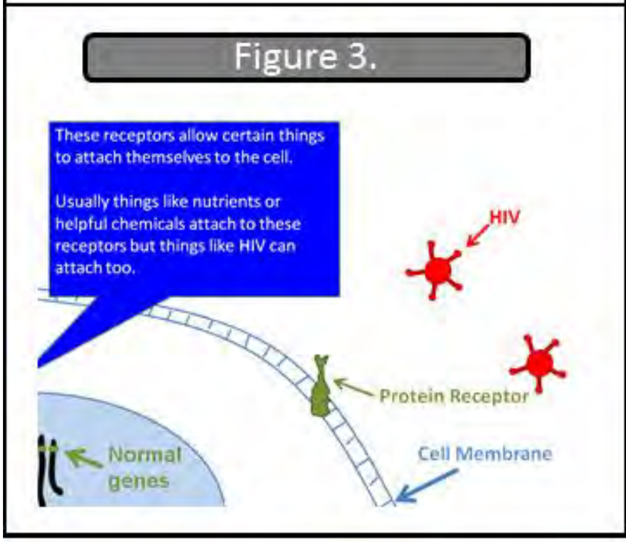
We used computer-based activities to enhance four aspects of our model-based inquiry curriculum including: the generation of data with simulations, enhancing authenticity of information by placing it in a context that is familiar to students, visualizing dynamic cellular processes, and multiple formative comprehension checks. Each figure below corresponds to one of these four aspects.

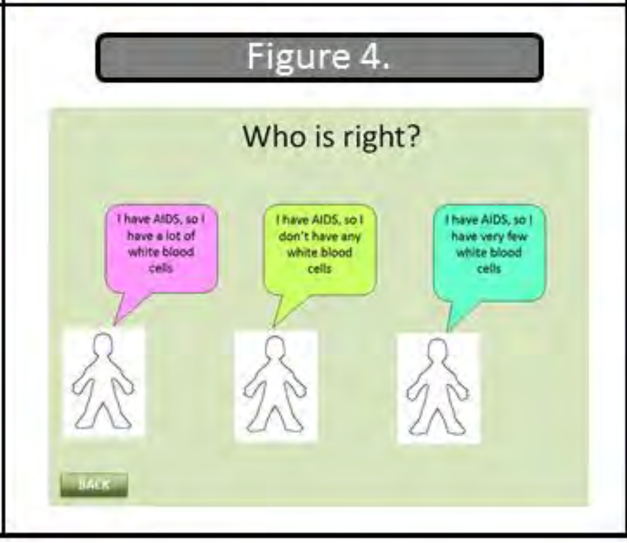
In a unit on cell organelles students considered the function of mitochondria. Students collaboratively used evidence to either support or refute two competing models about the function of this organelle. One model claimed that mitochondria are responsible for movement and the other posited that mitochondria generate energy for the cell. Figure 1 shows a simulation of ATP measurements of human runners measured at different time points in a training regime spread out over a number of weeks. Without the use of digital simulations this type of evidence could not be generated by students in the classroom. Figure 2 depicts an online advertisement for a quack medicinal cure for wrinkles through mitochondrial enhancement. Students read and discussed a series of email exchanges debating the merits of this treatment and the credentials of its purveyors. The email format enhanced the authenticity of this evidence by placing it in a context that is familiar to students. Other evidence was presented through blog entries for similar purposes of augmenting authenticity.

In another lesson students assessed two complex competing models of genetic resistance to HIV. Figure 3 is a still frame from an animation that was used to scaffold student understanding of the complex role of protein receptors in cell membranes and their relation to genetically based HIV resistance in humans. Prior research on students' learning in molecular genetics has shown that animations are effective for helping students learn about dynamic processes (Marbach-Ad, Rotbain, & Stavy, 2008). In the context of models of HIV resistance the use of an animation allowed students to visualize the underlying cellular and molecular mechanisms proposed by the competing models. Expert guidance, aimed at facilitating sense making during inquiry (Quintana et al., 2004), was also embedded in the animations in the form of prompts that draw students' attention to the salient comparable features of the two models of HIV resistance. Finally, we also embedded multiple formative comprehension checks of the models and evidence. These embedded assessments allowed both students and teachers to evaluate their understanding of core ideas presented in models and evidence and return to specific parts of the evidence when concepts, processes or mechanisms were unclear.

The use of digital animations of evidence and models allowed us to present more complicated mechanisms and experimental procedures that would have otherwise been too difficult for students to follow. Other forms of evidence, such as emails, online ads and blog posts, created a more authentic and familiar context, similar to the types of evidence students may encounter outside of the classroom. Lastly, these digital artifacts afforded a wider variety of model and evidence formats that students found to be engaging.







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That's Me and That's You: Museum visitors' perspective-taking around an embodied interaction data map display

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Abstract: CoCensus, a museum exhibit leveraging embodied interaction, allows users to collaboratively explore US census data on a large GIS display. We utilize tracking technologies to support personalized interactions, and we examine users' perspective-taking when discussing and interpreting the data display. Here pronoun use is analyzed to examine how the affordances of this technology facilitate connections between visitors and the social worlds represented by the data.

Introduction and Background

History museums strive to connect visitors' culturally situated "little narratives" to social and historical "big narratives" (Rowe, Wertsch, & Kosyaeva 2002). With CoCensus (Roberts, Radinsky, Lyons, & Cafaro, 2012), users pick an ancestry category, then approach an exhibit carrying a passive RFID tag which reveals their ancestry dataset on a large, interactive, shared display (Cafaro, Panella, Lyons, Roberts, & Radinsky, 2013). This paper explores one facet of narrative creation – positioning – during the collaborative exploration of the interactive map. We hypothesized that this design would encourage users' *actor* positioning (Brunyé, Ditman, Mahoney, Augustyn, & Taylor, 2009), demonstrated by visitors' use of first-person pronouns when referring to the mapped data. We use Brunyé and colleagues' (2009) framework for examining the perspectives taken by readers in their mental simulations of a narrative: readers take an *actor perspective* when they position themselves as participants in the scene, associated with the use of first-person pronouns (e.g. "I," "we"). An *onlooker perspective* is marked by third-person pronouns (e.g. "he," "they"). We assert that visitors' usage of personal pronouns can similarly elucidate the immersive depth and degree of embodiment in the narratives visitors construct with an interactive museum exhibit.

Methods and Analysis

While interacting, participants were asked questions about their interpretations, including "What do you see in this display?" and "Does anything you see in the display surprise you?" Responses were transcribed and coded to characterize the referents of speech. Transcripts were coded as evidencing an "actor" or "onlooker" perspective based on pronoun usage, in order to track the perspectives adopted by each visitor in their shared narratives constructed during the interview. A third code, "self," was used to document instances of visitors referring to themselves outside the context of the map, e.g. "I'm German." By contrast, a "data" code was used when visitors referred to the data on the map absent any personal connection (Figure 1).

We also tracked the ways each group utilized the space in the exhibit. Moving forward and backward affected the layering and transparency of the data shown on the shared screen. The further a user stood from the display, the more transparent her/his data were, and whoever was closest to the display saw her/his data "on top." A log file recorded the movements of each user in the space. Traces of visitors' locations during these three interviews are shown in Figure 1. Darker traces correspond to the locations were the user spent more time.

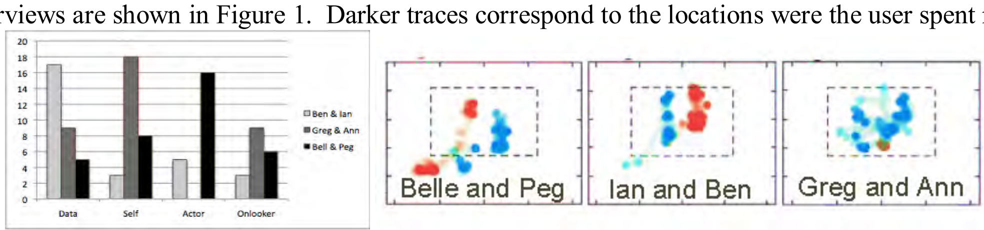

Figure 1. Frequency of perspectives (left) and traces of interaction patterns (right). The first listed participant in each pair is represented by red.

Findings

The three groups talked about the display in different ways, revealing different modes of interaction afforded by the exhibit. Belle and Peg assumed "actor" perspectives, e.g. "It looks like I'm along the Lake" (Belle), "And I'm not" (Peg). Sixteen of the 35 codes applied to their transcript were actor codes. This actor positioning was coincident with their movements in the space (Figure 2), suggesting that interaction may promote connections to the data.

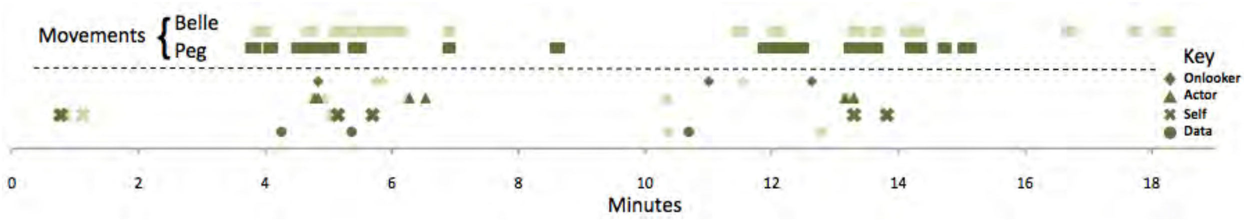

Figure 2. Timeline of Belle and Peg's movements in the exhibit space alongside pronoun usage.

By contrast, Greg and Ann did not assume the actor perspective. They talked about themselves and each other, including references to ancestry, but did not reference the mapped data as connected to themselves. Of all the visitors, Ann moved the most in the interaction space, seeming to be very engaged with the interactivity of the system. While she realized that she was able to control the data transparency, she frequently walked from left to right, despite the fact that side-to-side movement produces no effect on the display. Greg, in contrast, stood virtually still during the entire discussion. Their lack of understanding of the interaction design may have ultimately prevented them from engaging more personally with the data.

In between these two cases is the father-son pair Ben and Ian. The majority of the 28 codes applied to their interview were references to the data on the display, without reference to the people those data represent. They sometimes assumed the actor perspective, such as when Ian interpreted for his father, saying, "That's you, okay, see? The dark spots are where you and me are in the same place," but they minimally discussed personal stories, only adopting "self" and "onlooker" perspectives three times each. Instead, the majority of the interview was spent trying to make sense of the display. Ben and Ian were able to utilize the interactivity to "see" each other's data; that is, they were able to "instrumentally operate" the system (Williams, Kabisch, and Dourish, 2005). Ian moved forward and backwards, illustrating to his father which data were "him." Ben took longer to figure out how to interact with the system, looking for what he called "the optimal distance" from the screen, but eventually asked Ian to move in order to both see his "own" data on top and to explore their overlapping areas. It was only at that point that Ben switched to the "actor perspective" and embodied "his" data, but he still only did so for one turn.

Discussion

These three cases show different examples of how embodied interaction appeared to foster adoption of an actor perspective. When these museum visitors recognized their ability to instrumentally operate the system, they established a more direct and personal connection with the data they were controlling. The interaction design allowed visitors to explore the represented world "as embodied actors" (Dourish, 2001). This may afford the construction and sharing of personal narratives that incorporate data representations.

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Designing Community Knowledge in Fabrication Labs: Design Directives and Initial Prototypes

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Abstract: In this poster, we present our process of designing physical and digital supports for learning and community development in fabrication labs. Recognizing mere access to technology is not sufficient to bridge the digital divide associated with technological fluency, we conducted design research and developed initial prototypes to support equitable experiences across lab members. We share three design directives for community learning supports in fabrication labs as well as our initial prototypes.

Introduction

Every few decades, a new set of skills and intellectual activities become crucial for work, conviviality, and citizenship. In the early seventies, computer programming was one of them (Papert, 1991). The educational establishment derided the idea of *programming* as a fundamental pedagogical goal, but in recent years this idea has been challenged by easier to learn programming tools and the expansion of accepted disciplinary topics in K12 to engineering, design, and computer coding (Astrachan, Hambrusch, Peckham, & Settle, 2009). In 1999, the National Research Council suggested that fluency with technology should no longer be considered merely a vocational skill or a way to train future STEM workers, but we should regard it as knowledge valuable for every citizen, a claim that resonated with the concerns of Papert (1991) and diSessa (2000) around fluency with new media.

With the invention and increased affordability of such digital fabrication tools as 3D printers and laser cutters, fabrication labs are becoming ubiquitous across settings-- in schools, in community centers, and even in museums. The analogy of digital fabrication with computer programming is clear as these new technologies are becomingly increasingly accessible and their associated skills are more highly valued. As a result, many schools are adopting such programs across the country. However, the spaces where digital fabrication takes place (fabrication labs or maker spaces) require innovation in terms of how students build knowledge together. Most of these spaces are the collection of improvised sets of tools and environments, which work well for experts but could not work for novices. As Pinkett (2000) articulates, "Access does not imply use, and use does not imply meaningful use, we must also consider the nature of engagement we seek to promote." Equity issues arise when adequate support is not available. As Blikstein (2013) demonstrated, such environments disproportionately benefit male students, learners from high-income schools, and students with parents with an engineering background. In order for a fabrication lab to thrive and support all types of students, we must build and nurture the social and cultural experience in addition to providing the equipment and physical space. In this paper, we will address the design of spaces for collaborative and project based-learning, with a particular focus on issues of equity and inclusiveness. We borrow from the sociocultural constructionism framework developed by Pinkett (2000), which emphasizes the role of community members as active change agents and knowledge producers within a learning context.

Design-based Research and Initial Prototypes

The first author conducted design research in the fabrication lab prior to having participated in the lab in any capacity. This novice's perspective, by design, allowed for insights to surface that more immersed others may not have perceived. Through observations and interviews with various lab users, including lab assistants, current graduate student lab members, high school workshop students, newcomers to the lab, and lab alumni, we developed initial directions for space design prototypes. Below, we describe the ideas that emerged from this design research and how we fashioned these insights into design directives for the lab space.

In fabrication labs, students tinker and build to discover the myriad constraints and affordances of lab materials and equipment. In the process, they adopt and adapt techniques for realizing their project visions. Observations in our fabrication lab indicated that such discoveries were primarily individual experiences and were opaque to other lab members. During open lab time, when students who did not know each other occupied the space, there were few moments of sharing and discussion. Despite this lack of interaction, when the opportunity arose, lab members were eager to share discoveries with each other. For instance, we observed a former student excitedly relaying an insight he discovered through trial and error to a student he noticed etching text into clear acrylic, which was an element of his own class project the prior year. In this case, knowledge sharing occurred due to happenstance. We viewed this as an opportunity to design ways for students to "stumble across" more knowledge sharing moments.

One might assume that lab assistants, who have the most pervasive presence in the fabrication lab space, would act as mediators of the knowledge that individual students derive from their experiences in the lab. However, we noticed that students of all experience levels approached lab assistants primarily to ask one question: Where is "x"? The second most common question type was related to general machine usage. Not only were the answers to such common questions highlighted in the equipment training materials, but these questions could be answered by any number of lab members. Again, we viewed this as an opportunity to design easy entry points for lab members to interact with each other and collaboratively find solutions. This insight, again, pointed to the need for more scaffolds to support lab member sharing and co-discovery. With these findings in mind, we generated three design directives: 1) How might we make student work more visible? 2) How might we facilitate lab member introductions? 3) How might we provide scaffolds for just in time sharing of small discoveries? As a way to test our design directives, we created digital and tangible prototypes, of various levels of resolution, with materials such as paper, cardboard, and existing tablet applications.

Hargadon and Sutton (2000) refer to the term *knowledge brokering* as a strategy that the most innovative groups adopt wherein people are able to borrow from previous ideas and repurpose them for future use – using "old ideas as the raw materials" for new ones (Hargadon & Sutton, 2000; p. 158). In the context of the fabrication lab, we view prior project work across lab members as "raw materials" to spark new ideas. In addition to providing display space for actual projects, we aimed to create a persistent digital memory of all of the projects created in the lab via tablets mounted in the space. With Twitter hashtags and visual Twitter feed applications, students are able to share photographs of their projects on Twitter, which would simultaneously be broadcast to tablets placed strategically in the space (Fig.1, left).

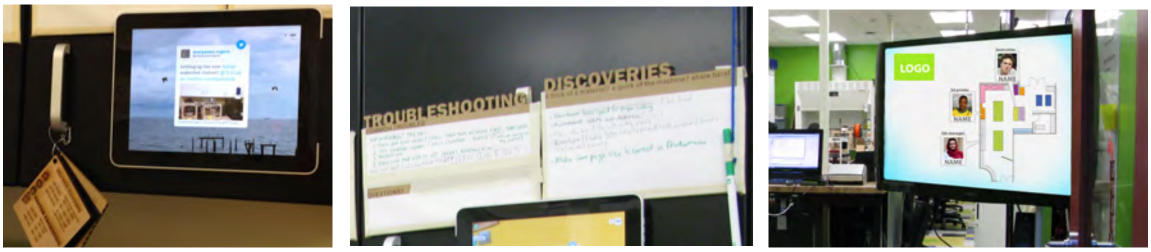

Figure 1. (left) A dynamic, visual Twitter feed creates persistent memory of what was created in the fabrication lab; (mid) a paper prototype supports just-in-time sharing of discoveries in the lab, (right) a visualization of lab members currently in the fabrication lab makes individual expertise transparent.

As noted above, we observed that lab members had been reticent to approach unknown lab members unless they were in the midst of an activity that related directly to their own experience. This lack of interaction concealed the diverse areas of expertise distributed across lab members. In response, we prototyped a dynamic visualization of individuals using the lab space (Fig. 1, right). Via an online schedule and RFID tags, which lab members use to "check in" to various stations, members entering the lab could see with a quick glance how many people were in the space, their background, and their lab expertise. Finally, in order to support just-in-time sharing of individual insights, we posted signage above the laser cutter station with heuristics for using the equipment and for sharing new discoveries about the equipment (Fig. 1, middle).

Conclusion

Through design research conducted in a collaborative fabrication lab, we derived three design directives, and created three prototypes in the collaborative space to address knowledge visibility, expertise identification, and knowledge sharing. We are continuing this work by testing the effectiveness of each component, and devising new artifacts based on our evolving research in these spaces.

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DynaLabs for Teachers to Collaborate on Pedagogical Strategies

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Abstract: Developing students' argumentation skill is now important in many countries. We report on new tools for teachers to construct, share, and iteratively refine idealized dialogues with imagined students. Such tools can become the heart of a laboratory experience in which teachers collaborate around their possible responses to student reasoning. Our design-based research suggests a laboratory experience for teachers should include four components: a case that challenges teachers, research-based resources that can inform teachers' thinking, a tool for respond constructively to the challenge, and a rubric for formative assessment.

Major Issue Addressed

Engaging students in learning 21st century skills is a major thrust of educational reform globally. From the CSCL perspective, one of the most relevant 21st century skills is *argumentation* – using discourse to explain and justify reasoning and to engage others in collectively improving the group's reasoning (Andriessen, Baker & Suthers, 2003). Another highly relevant skill is *model-based reasoning* – using simplified, abstract representations to reason more effectively about more complex underlying situations (Lehrer and Schauble, 2006). Argumentation and model-based reasoning are now specifically identified as mathematical practices that characterize successful student reasoning in the new Common Core State Standards in the United States.

In the context of our Proportionality Dynabook project, we have been conducting design experiments relevant to this challenge at two California universities that prepare future mathematics teachers. California is in the midst of transitioning to a "clinically-based model" of teacher professional development, which aims to engaging teaching candidates in situations that authentically elicit the "problems of practice" (Darling-Hammond, 2008). This includes supervised field experiences for preservice teachers, but also includes the idea of simulating real teaching during coursework.

In this poster, we report on a particular insight arising from design research: that new tools for teachers to *construct, share, and iteratively refine* idealized dialogues with imagined students can become the heart of a *DynaLab,* a laboratory experience in which preservice teachers collaborate in order to understand what teaching argumentation, model-based reasoning, or other advanced practices might look like at the level of teacher-student interactions. We focus on one of several labs under development, a lab in which teachers read and discuss the research-based learning progression for the concept of *ratio,* then watch a video of a student struggling to solve a ratio problem, then in collaborative dyads develop a script for how they would teach that student, and engage in formative assessment.

Potential Significance

We see our contribution as deeply reflecting the conference theme, "to see the world and a grain of sand." At the "world" level, policy documents are changing to reflect the importance of new kinds of knowledge and skills. Yet, the important acts of teaching and learning that develop these skills often occur at the "grain of sand" level. New activities and tools, such as we propose in our DynaLab concept, are necessary to enable teachers to connect broader goals to specific classroom practices.

Methodological Approach

The methodological approach in our Dynabook project has been Design-Based Research (DBR, Cobb et al, 2003) – our process aligns with Wang and Hannifan's (2005, p. 6) characterization of DBR as "a systematic but flexible methodology aimed to improve educational practices through iterative analysis, design, development, and implementation, based on collaboration among researchers and practitioners in real-world settings, and leading to contextually-sensitive design principles and theories." Our specific approach to DBR emphasizes *co-design* (Penuel, Roschelle & Shechtman, 2007) between researchers, technologists, and practitioners.

A DynaLab Design using Dynalogue

Schematically, a DynaLab has four components. First, a DynaLab has a plan with specific objectives and accompanying materials that stimulate or elicit the participants' engagement with an open-ended "problem of practice." Ideally, such materials should evoke authenticity and present opportunities for collaborative work among teachers. Second, a DynaLab has research-based knowledge resources which can help participants to learn how to better address the problem of practice. Third, a DynaLab has specific tasks aligned with objectives that give participants the opportunity to respond to these challenges collaboratively, to compare and critique their solutions, and to engage in reflection and refinement of their solutions. In particular, a DynaLab activity engages participants in constructing a detailed artifact as their response. Fourth, a DynaLab has an assessment rubric that can be used for formative assessment, to improve the solutions and to improve the design of the lab, and the discourse that evolves in the process. The most innovative feature of our design is "Dynalogue," a new tool for writing, sharing, and revising dynamic dialogues. As shown in Figure 1, the dialogue is written in bubbles that are spoken by two animated characters, in the style of familiar smartphone messaging tools.

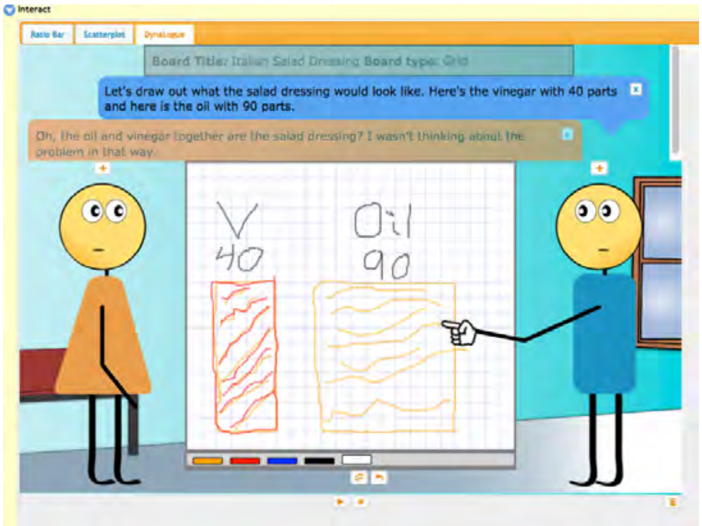

Figure 1: A Dynalogue, showing how a teacher might use a visual model to interact with students

Preliminary Findings and Next Steps

We have found that the DynaLab concept is highly attractive to teacher educators who are charged with preparing a new generation of mathematics teachers. The DynaLab concept is seen as useful as it is grounded in authentic problems of practice but allows for cycles of constructing, sharing, reviewing, and refining teacher-student dialogues within the structure of existing teacher preparation courses. Going forward, more research is needed to establish the comparative advantage of DynaLabs for developing teachers' knowledge and pedagogical skills, relative to other forms of teacher professional development.

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Automated and Adaptive Support for Educational Discussions: Results to Guide in Making this a Reality

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Abstract: A potential way to enhance CSCL systems with adaptive support is to capitalize on the pre-structuring of student input that comes from the use of sentence openers and diagram references. An analysis of students' use of structuring elements reveals differences in the level of their adoption and a variety of ways in which students interpreted their task and used the learning environment for their purposes. We discuss possible enhancements to facilitate automated interpretation that might guide students towards more effective discussions.

Introduction

A focus in CSCL has been on promoting high-quality forms of argumentation (Scheuer, Loll, Pinkwart, & McLaren, 2010). Precondition for *adaptively* supporting argumentation is the complex task of analyzing verbal discourse automatically. We explore the potential of two structuring elements to facilitate such automated analyses: *sentence openers* (*SOs*) and *argument diagrams*. Combining these two elements helps classify chat contributions along two crucial dimensions: (1) *communicative intentions* (through SOs), and (2) *propositional content* (through diagram references; *DRs*). We present results regarding students' use of SOs and DRs and discuss changes to our learning environment that would maximize the amount and precision of information that can be derived from student discussions. The goal of our research is to use inferences made from a heuristic interpretation of SOs and DRs to inform automated feedback to help students have more effective discussions.

Background

SO-based interfaces are designed to encourage specific interaction patterns considered conducive to learning. Students choose from short predefined phrases when composing new messages (e.g., "I disagree because," and "Can you explain why/how"). It has been proposed to also exploit SOs to make inferences regarding dialogue structure and meaning (Soller, 2001). Yet, there are several problems in the interpretation of SOs. (1) When the use of SOs is optional, students might not use them, so no inferences can be drawn (Lazonder, Wilhelm, and Ootes, 2003). (2) When the use of SOs is obligatory, students might misuse them when none of the offered choices satisfies their needs (Soller, 2001). (3) Even if the SO matches the message body, multiple interpretations might be possible (Lazonder et al., 2003). (4) Messages might express multiple ideas at once, which not only violates guidelines regarding efficient communication but also hampers the interpretation of SOs (Israel & Aiken, 2007). Our second structuring element is argument diagrams. Diagrams decompose the discussion domain into referable chunks of knowledge (e.g., claims, arguments, and facts). While students use the diagrams as a resource and guide during their discussions (Suthers & Hundhausen, 2003), they can also explicitly *refer* to diagram elements, e.g., to create a joint focus of attention with their learning partner.

Method

The study used a control group design with 22 dyads. Dyads used the LASAD argument-diagramming system to analyze and discuss two conflicting texts on climate ethics. The learning task comprised four phases: analyzing (phase 1; individual), discussing (phase 2), and interrelating (phase 3) the two texts with the goal to generate a joint conclusion (phase 4). The treatment group (12 dyads) used the full version of the system including a chat tool with SOs. The control group (10 dyads) used an ablated version of the system with a standard chat with no SOs. As for SOs, we analyzed the treatment group alone (the control group did not include SOs). As for DRs, we analyzed phases 2 and 3 only (phase 1 is an individual phase; phase 4 is about students' own opinions with less need to use DRs). DRs were coded based on references to diagram box numbers in the chat. Results regarding process and learning are reported in Scheuer, McLaren, Weinberger, and Niebuhr (in press).

Results

Students used an SO in one out of five chat messages (20%) with notable differences between dyads: five dyads made frequent use (> 25% SO messages), three dyads made occasional use (> 10% SO messages), and four dyads rarely used SOs (< 10% SO messages). Note that 25% SO messages is already considerable since a substantial portion of each discussion (about 1/3) is not about the subject matter. Students within the same dyads significantly influenced each other in terms of the extent of SO uses ($ICC = 0.83$; $F = 10.6$; $p < .001$). That is, if one student decided to use (or not use) SOs, it was very likely that the other student decided so as well. Although students rarely misused SOs (4%), some SOs were used with varying meanings. For instance, the SO

"Could you explain to me" was used not only to elicit explanations in a neutral way, but also to raise concerns or objections against previous points. The SO "For instance" was used not only to illustrate some previous point, but also to list one or more exemplary arguments to support a previous point. Some messages expressed multiple independent ideas at once. For instance, some students presented an argument and asked a question within the same message. In other cases, students provided several independent reasons to support a claim in the same message. Finally, the point of reference of messages was not always clear. For instance, sometimes the SO "A supporting argument is" was used to present an argument regarding a recent claim. In other cases, they referred to the general discussion topic. In either case, supporting SOs are typically used to support one's own position and opposing SOs to oppose the partner's position, a useful heuristic.

Across all dyads about 12% of all messages contained a DR, again, with notable differences between dyads: five dyads made frequent use (> 25% DR messages), five dyads made occasional use (> 10% DR messages), and twelve dyads rarely made use of DRs (< 10% DR messages). That is, almost half of all dyads (45%) used DRs in their contributions at least occasionally. A rate of 10%, or even 25%, is substantial, since about 1/3 of all messages are not about the subject matter. It is also not unusual that students exchange multiple messages regarding one and the same diagram element. Also, we did not require that students use DRs, we only hinted at the possibility to do so. DRs were used in a variety of ways. For instance, DRs were added to messages to cite the diagram element as the source of the information used in the message, to comment on the content of a diagram element, or as a shortcut / placeholder for the content of the referenced element, which saves the effort of typing the entire statement of the DR into the chat. One student complained about this practice, annoyed with searching for the referenced contents in the diagram. Finally, students had different approaches about where to post DRs: in the very message that contained a statement based on or related to the referenced element, or in a separate message before or after that message.

Discussion

In summary, we found that most students made reasonable use of SOs and DRs. Whether the extent of use provides sufficient information to effectively support students with automated feedback is an empirical question still to be investigated. Even if students make frequent use of the provided structures, they may use them in different ways, giving rise to multiple possible interpretations, a difficulty in generating precise feedback. A more effective and uniform usage may be achieved through: (1) *message categories* (clearer interpretation of intention compared to SOs), (2) *threaded discussions* (unambiguous point of reference of messages), (3) *more explicit instructions* (clearer expectations), (4) *incentives for use* (e.g., highlighting of referenced diagram elements when hovering over chat messages to save time-consuming search in the diagram), and (5) *explicit feedback* (e.g., sending of messages to students who rarely use SOs).

The generation of effective feedback is only one concern in the design of adaptive CSCL systems and sometimes is at odds with usability and pedagogical concerns. That is, improving the precision of an automated analysis may lead to undesirable side effects. Some relevant tradeoffs are: A more restrictive script / user interface may: (pros) (1) provide better-structured user inputs to inform the automated analysis of interactions in a more precise way and (2) guide students towards modes of interaction closer to the ideal model of interaction the instructional designer had in mind vs. (cons) (1) lead to more mechanical and unnatural forms of interactions, or obstruct fruitful forms of interaction, and (2) lead to user frustration, decreased engagement, and unintended forms of use, particularly when users perceive the structure as a burden rather than an aid.

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Comparing "in the Wild" Studies With Laboratory Experiments: A Case of Educational Interactive Tabletops

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Abstract: In this paper, we describe our attempt at implementing an interactive learning activity on a multi-touch tabletop in an actual college classroom. In our previous in-lab experimental study, we found that this tabletop learning activity outperformed the same learning task on paper. Students had a higher quality of collaboration and learnt more when interacting with an interactive multi-touch tabletop display. Here we compare those results with an "in the wild" implementation of our system. We found that learning gains were significantly lower in the classroom compared to a laboratory setting. Our paper investigates this difference and suggests reasons for such a discrepancy.

Introduction

The introduction and increasing availability of multi-touch, high-resolution displays in the form of handhelds, tabletops, and whiteboards, open the opportunity to consider these technologies as a prominent alternative to current learning technologies. Given the potential of these novel technologies, numerous research prototypes have been developed by Human-Computer Interaction researchers, exploring how these emerging technologies will impact education. However, to date, only a small fraction of prototypes have materialized outside of research lab settings and studied in actual classroom settings. A foundational work in this domain was presented by Brown (1992), who introduced *Design Experiments* as complex interventions implemented in educational settings. This approach generated controversy due to the large number of confounding variables present in classrooms. However, Brown was able to identify the fundamental tensions between a natural and artificial setting. Many researchers followed her example and recognized the importance of testing educational interventions in an ecological way. However, to date, little research has been devoted to investigating the strengths and limitations of utilizing interactive surfaces in college-level learning.

Comparing Laboratory and Classroom Experiments

Phylo-Genie, a learning activity to help college-level students grasp basic concepts in phylogenetics, is implemented on an interactive multitouch tabletop display (Microsoft Surface^{TM}). This work has been previously presented at the ACM SIGCHI conference (Schneider et al., 2012). In particular, Phylo-Genie provides students opportunities to build their own phylogenetic trees through a learning scenario.

In this section we summarize the two studies that we conducted to evaluate Phylo-Genie. The first study, a controlled experiment, was completed in a laboratory setting with college-level students; the second, in-class study, was conducted in a college classroom.

Participants: *controlled experiment:* 28 undergraduate and graduate students (28 female, 28 male, average age = 21.28, SD = 3.70) volunteered to participate in the study, composing 14 dyads. *Classroom setting:* 32 students, enrolled in an introduction to biology course in a women college (all females), participated in our study. None of the participants had received college-level instruction in evolutionary biology before the study.

Materials: The materials used in both studies were similar. A post-test was provided by a university professor who teaches introductory phylo-genetics to college-level students. We rated the quality of collaboration among dyads by using Meier's rating scheme (Meier, Spada & Rummel, 2007).

Procedure: We conducted the experiment in two private laboratory spaces for the controlled experiment, and in the classroom for the second study. Subjects received a 5-minutes introduction to phylogenetics before the Phylo-Genie activity. They then went through all the steps of the learning scenario and completed a post-test. Each session was approximately 60 minutes long. Due to limitations in hardware availability, some students had to work in groups of three in the classroom condition.

Results: we found that students in the laboratory setting outperformed students in the classroom on the learning test: $F(1,58) = 4.32$, $p < 0.05$ (mean=0.9, SD=0.11 for the laboratory, mean=0.83, SD=0.13 for the classroom).

We also rated the quality of collaboration of each dyad participating in the tabletop activity in the classroom and in the laboratory according to Meier's, rating scheme (Meier, Spada & Rummel, 2007). We found that overall, students had a better quality of collaboration in the classroom: $F(1,16) = 4.26$, $p = 0.056$, eta squared = 0.21 (for the classroom, mean = 21.00, SD = 8.68; for the laboratory, mean = 13.67, SD = 6.19).

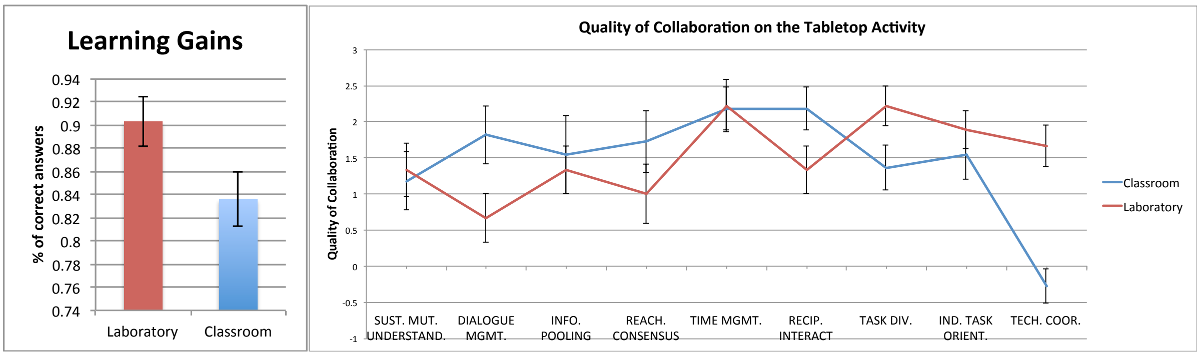

Figure 1. Quality of collaboration in each group and setting (based on Meier's rating scheme).

The sub-dimensions *dialogue management* ($F(1,16) = 16.67$, $p = 0.001$), *reaching consensus* ($F(1,16) = 5.50$, $p = 0.032$), *reciprocal interaction* ($F(1,16) = 7.27$, $p = 0.016$), *task division* ($F(1,16) = 3.16$, $p = 0.094$, eta squared = 0.035) and *technical coordination* ($F(1,16) = 4.26$, $p < 0.001$) showed a statistical difference (Figure 1). Interestingly, only *task division* was correlated with a positive learning gain across our two groups.

An interesting detail is that the five lowest scoring students in the classroom (in terms of learning gains) were all in different triads; compared to the mean learning-gain score of the classroom tabletop condition, two of these students were below two standard deviations, one was below one standard deviation and the remaining two were within one standard deviation of the mean. If we remove the two outliers (lowest scoring students) from the analysis, the difference in terms of learning gains between the classroom and the lab conditions become non-significant: $F(1,56) = 2.45$, $p = 0.123$. We also have more data concerning students' territoriality and discourse, but due to space constraint we cannot describe them here.

Discussion

Our initial results suggest that triads seem to be more likely to have one "weak" student in the group. We believe that these students were not less able, but they may have been excluded (to some extent) from the rest of the group. The "task division" sub-dimension of the collaborative rating scheme was able to detect this difference between dyads and triads. More fine-grained studies should look at how students in triads become disengaged or get excluded from the learning activity.

Our preliminary results suggest that *hardware availability* may have caused students in the classroom to learn less than in a laboratory setting. By having students work in triads instead of dyads, groups were more likely to have a "free rider" (e.g. a student who does not engage in the activity). This effect is described by Salomon & Globerson (1989), where implicit coalitions are detrimental to collaborative learning. From a technical standpoint, this is a critical issue. Interactive tabletops are expensive, and most schools cannot afford to buy multiple devices. Consequently, researchers should pay a special attention to the ratio of interactive tabletops per students when implementing this kind of technology in the classroom. For future work, we plan to conduct more in-depth analyses of students' interaction to unpack (and suggest ways to prevent) group coalition in the classroom.

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Come_IN@Palestine: Adapting a German Computer Club Concept to a Palestinian Refugee Camp

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Abstract: The come_IN computer club is an approach to foster learning and integration in intercultural neighborhoods of Germany. We have tried to adapt this concept to a different part of the world: a Palestinian refugee camp. Similar to intercultural German neighborhoods, refugee camps are also the result of migration moves, however, in this case of an enforced one. Our findings indicate a successful adaptation of the approach to a Palestinian context.

Introduction

The intercultural computer clubs, called *come_IN*, offer a place to share practices among children and adults of diverse ethnical backgrounds. Once a week the participants voluntarily gather in the computer club, work on joint projects, study, play, or realize individual ideas supported by the use of information and communication technology (ICT). Together the participants are creating personal meaningful artifacts to express themselves (Schubert & Weibert 2012). These situated and shared practices are apt to develop an effect on an individual as well as on a community level (Veith et al. 2009). Via computer supported project work the club participants can establish new social contacts, learn about the ideas of the other participants – within their own and from different cultures. Since 2003 we have built a network of come_IN intercultural computer clubs in Germany (Schubert et al. 2011). The main goal of this work is to investigate into the transfer of our experiences from the German context and adapt it to the specific needs of Palestinian refugee camps and their inhabitants. Through the use and appropriation of ICT these marginalized Palestinian refugee communities can positively engage into their own society and in the Palestinian-Israeli conflict-to-peace transformation process. Another major objective to transfer our approach and to build a network of computer clubs among refugee camps is to network Palestinians across different sites, at the same time promoting their integration into the local societies and finally enabling their access to the information society.

State of the Art

The concept of the come_IN computer clubs follows the tradition of computer clubhouses in the US. The first of these computer clubhouses was established for underprivileged youth in Boston in the year 1993; the principles of situated, collaborative learning and constructionist thinking offered them opportunities to express themselves with the use of ICT and new media (Kafai 2009). The pedagogical concept behind the clubhouses is an extension of the constructivist-learning paradigm, known as constructionism (Papert 1980). The come_IN approach developed this concept further, applying it to issues of inter-generational learning and the integration of migrant communities in Germany. The computer clubs were based in schools, which serve a central point of exchange among the people of the city district, to provide opportunities for elementary school kids, their parents and tutors to engage in group-oriented project work. The digital divide between the students in a refugee camp and those outside is obvious. The term "digital divide" was defined by Mehra (2004) as "the troubling gap between those who use computers and the Internet and those who do not." To narrow this digital gap and empower the students in the refugee camp Sawhney (2009) hosted over three years several workshops about storytelling in Palestine. Storytelling can also used to work through intractable conflicts; this enables people with traumatic social experiences to digest these experiences and learn to live with the happenings. Bar-On (2004) demonstrated with a Palestinian-Israeli group that storytelling could help to handle painful events.

Jalazone: A Palestinian Refugee Camp in the West Bank

Jalazone is a Palestinian refugee camp in the West Bank approx. 7 km north of Ramallah. Like most of the other refugee camps Jalazone was established in 1949. The inhabitants of the camp were expelled or fled from their homes in nowadays Israel. A high population density as well as crowded and precarious living conditions characterizes the camp. The unemployment rate is at a very high level (40% compared to the average of 20 % in the entire West Bank). The council running the camp estimates that approx. 30% of the families have Internet access at home. There are also some Internet cafés. These places have a bad reputation since they were rarely controlled by adults and considered to be used for computer gaming, gambling, and pornography watching.

Research Methods

Grounded Theory (Strauss & Corbin, 1990) was chosen as a theoretical framework to be grounded in the field. Also we adhere to principles of Participatory Action Research by Kemmis & McTaggert (2004) regarding the question “how to act in the field”. With this approach we as authors were part of the field to investigate meaningful, field-oriented insights. We conducted the research presented in this paper over a period of 28 months, from May 2010 to September 2012. The first visits were documented via field notes and photos. Extensive documentations were written every evening of the respective day. At the last visit an accredited translator was part of the research team, so it was possible to do workshops and interviews in Arabic with the tutors, the children and inhabitants of the refugee camp. During our last stay in August and September 2012 we conducted 7 semi-structured interviews (with durations between 30 minutes and 3 hours) and more than ten informal interviews, almost all of them were audio recorded. Additionally protocols from the weekly computer club sessions written by the tutors and other materials have been collected.

Discussion and Conclusion

While the come_IN approach itself was inspired by Resnick’s (1996) work, it was yet another stretch to move this socio-technical approach to learning and social integration to a Palestinian context. The challenge was to share insights gained in Germany while adapting the socio-technical concept to the different context. We assumed that our publications and written materials would only provide limited insights into our experiences made during almost ten years of project work. Therefore, we very much believed in an exchange of expertise among the partners at different points in time. Different members of the German project team spent substantial amounts of time in understanding the local context and preparing for the clubs opening. Moreover, we invited the Palestinian project manager for one week to Germany to make him see the computer clubs in action. In the West Bank, we have decided to work with a local university, Birzeit, to build the club, which adds a second university player into the support structure. While they coordinate the local activities and engage undergraduate students to tutor the club, their social attribution in the camp is quite distinct. In future visits we want to evaluate the further development of the computer club and its participants within and outside the refugee camp. To became a network the opening of further computer clubs within the West Bank is planned as a long term perspective.

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Extending the Reach of Embodied Interaction in Informal Spaces

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Abstract: Exhibit designers in informal institutions are exploring the potential educational benefits of embodied interaction experiences. But are these exhibits—often relying on a single user for control—practical for settings with thousands of daily visitors? We present results from an observational study of an embodied interaction exhibit at a major zoo, focusing on how to make single-user embodied performances more inclusive and participatory for spectators.

Background

Zoos and museums have a long history of providing interactive learning experiences to visitors, and have been exploring more "naturalistic" embodied interaction approaches, from tangible user interfaces to whole-body interactives (Alisi et al., 2005). Embodied interaction is thought to confer usability benefits, but most designs only allow a small proportion of visitors to directly participate. However, thousands of visitors might encounter an exhibit in a day, so designers must extend the experience so that it is beneficial for non-participating spectators. This paper builds on existing work on extending spectator experiences, which has stressed increased display size (Diamond et al., 1995) and visibility of user/system interaction (Reeves et al., 2005). Spectators need to know what the participant is doing, and how it affects the system, to understand what is happening. Many embodied interactions unintentionally obscure this information, as the kinesthetic nuance is felt only by the person in control. In this work we explore how "visible" the lessons of existing single-user embodied designs are to spectators, and explore how to extend that "visibility".

Our exhibit prototype, *A Mile in My Paws*, uses physical effort to illustrate the challenge polar bears face as they react to the changing climate. Zoo visitors control a polar bear avatar that must traverse the arctic environment in multiple sessions of past, present, and future time periods, as they search for food. Users control the bear by "swimming" with weighted motion-sensitive gloves (fashioned as plush polar bear paws) and walking in place on a pressure sensitive plate. As sea ice decreases over time, polar bears must work harder to travel the same distance, as they burn more calories swimming versus walking. This embodied experience is intended to prime learners for understanding the rate and magnitude of climate change (Lyons et al., 2012).

Methods

The *Paws* game was deployed in the underwater polar bear viewing area at Brookfield Zoo in Chicago, IL. The pilot data in this paper was gathered during two days of deployment, where the *Paws* interactive exhibit was available for use by the visitor population for a period of roughly one and a half hours each day. Ten zoo interpreters joined the research team across the two days, working as a team to run the exhibit. Zoo interpreters vary in age and experience, and are typically in charge of explaining phenomena at exhibits, answering questions, and facilitating specialty content like scheduled talks and specimen carts.

Interpreter and visitor behavior was captured through video and audio recordings. On the second day, interpreters passed out simple paper ballots for visitors to indicate whether they thought swimming or walking was more difficult for the polar bear—a key learning goal for the *Paws* exhibit, but one which is non-obvious to non-playing observers, who cannot feel the difference in effort while swimming versus walking.

Results & Discussion

Since the *Paws* game relies on the player's perception of effort to convey the difficulty that polar bears are facing, our initial concern was that not all visitors would have access to this embodied experience. During the pilot, 26 visitors played as the virtual *Paws* bear, but this was only 2% of the 1049 total visitors who passed through the space (see Figure 1 for visitor participation with *Paws* over time). Using the paper ballots, we compared the responses of *Paws* players and non-players; while 82% of the players (9 of the 11 surveyed) answered correctly that swimming was more difficult than walking, only 70% of non-playing peripheral audience members (21 of the 30 surveyed) produced this response. This indicated to us that visitors who didn't have the opportunity to embody the polar bear needed additional support to learn from the *Paws* exhibit, since they didn't have direct experience of the relative difficulty of swimming versus walking.

Our first strategy for engaging non-playing spectators was "pantomiming"—having visitors mimic the swimming and walking actions of the person playing the game. This activity was created by the zoo interpreters during the design of *Paws*, as a means for supporting peripheral participation. While child visitors didn't spontaneously engage in pantomiming, they participated enthusiastically when prompted to by interpreters.

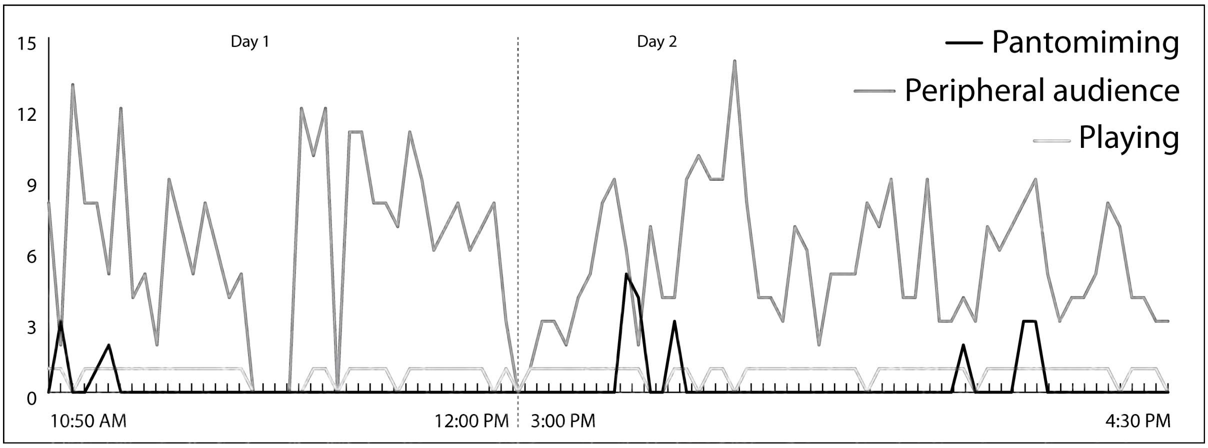

Figure 1: Number of playing, pantomiming, and peripheral visitors during the pilot.

When we gave the paper ballots to children who had pantomimed, 75% of them (9 of the 12 surveyed) marked that swimming was more difficult, an improvement over the more peripheral spectators. Using a Kruskall-Wallis analysis of non-parametric variance to compare the playing, pantomiming, and peripheral (non-playing/non-pantomiming) groups, we found that the difference between groups is significant with $p < 0.001$ ($K=34.6$, $df = 2$). The drop-off in correctness among these groups suggests that while spectators are generally able to figure out the core, embodied message of *Paws*, visitors that engage in pantomiming have additional but indirect access to the *Paws* player's experience. Pantomiming supports multiple simultaneous visitors, and could be further enhanced by giving pantomimers "dummy" weighted gloves disconnected from the system. Thus, pantomiming is a promising approach for helping an extended audience directly experience the kinesthetic differentiation between swimming and walking.

The downside to the pantomiming activity is that adults would not engage in pantomiming, even when it was encouraged by interpreters. Adult spectators would therefore require a different approach to engage them in the activity and make the player's kinesthetic experience "visible". We thus designed a mobile tablet app to facilitate discussion around *Paws* for non-pantomiming spectators. The interface included a live map of player progress and graph of the bear's simulated caloric expenditure. Our expectation was that by making visible multiple representations of the player's current state, this would allow an alternative access point for adults (and potentially some children) who might not want to participate in pantomiming. Interpreters were aided in scaffolding discussion around climate change through pop-up questions on the tablet as well as by being able to select information from the tablet to present on a large shared display. Although the tool was designed for spectators' needs, interpreters also used the tablet to interact with pantomimers and the visitor controlling the bear. Interpreters' decisions around what information to display or mention may reflect their dynamic judgments about what would be most engaging for visitors at different participation levels. Our team is in the process of analyzing the interaction between interpreters, visitors, and the mobile support tool, to see how learning with the alternate representations compares to the embodied learning that players and pantomimers engage in.

Our results indicate that for zoos to engage multiple audiences in exhibits with participatory, embodied content, they need to pursue multiple simultaneous strategies for different audiences. In our case, pantomiming affords child visitor interaction with *Paws*, but engaging adult spectators required a different strategy. We found success with a mobile support tool that displayed the player's progress and effort. These strategies enabled a wider audience of visitors to access and learn from a single-user interactive exhibit.

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Discovering Dependencies: A Case Study of Collaborative Dynamic Mathematics

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Abstract: The Virtual Math Teams (VMT) Project is exploring an approach to the teaching and learning of basic school geometry through a CSCL approach. As one phase of a design-based-research cycle of design/trial/analysis, two teams of three adults worked on a dynamic-geometry task in the VMT online environment. The case study reported here analyzed the progression of their computer-supported collaborative interaction, showing that each team combined in different ways (a) exploration of a complex geometric figure through dynamic *dragging* of points in the figure in a shared GeoGebra virtual workspace, (b) step-by-step *construction* of a similar figure and (c) discussion of the *dependencies* needed to replicate the behavior of the dynamic figure. The teams thereby achieved a group-cognitive result that most of the group members might not have been able to achieve on their own.

Based on a Vygotskian perspective, our CSCL approach to the teaching of geometry involves collaborative learning mediated by dynamic-geometry software—such as Geometer's Sketchpad or GeoGebra—and student discourse. During the past decade, we have developed the Virtual Math Teams (VMT) environment and have recently integrated a multi-user version of GeoGebra into it (Stahl, 2009; Stahl et al., 2010). Our environment and associated pedagogy focus on supporting collaboration and fostering significant mathematical discourse. In developing this system, we have tested our prototypes with various small groups of users. Recently, two small groups worked together on a problem based on the construction of inscribed equilateral triangles (see Figure 1).

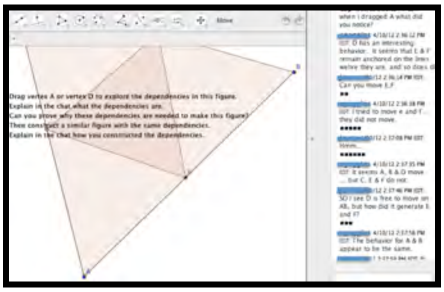

Figure 1. Discussion of the inscribed triangles problem.

The geometry problem is adapted to the VMT setting from (Öner, 2013). In her study, two co-located adults were videotaped working on one computer screen using Geometer's Sketchpad. We have "replicated" the study with teams of three adults working on separate computers with our multi-user version of GeoGebra in the VMT environment, allowing them to construct, drag, observe and chat about a shared construction. Öner chose this problem because it requires students to explore a dynamic-geometry figure to identify dependencies in it and then to construct a similar figure, building in such dependencies. We believe that the identification and construction of geometric dependencies is central to the mastery of dynamic geometry (Stahl, 2012b; 2013).

In this study, we analyzed the processes through which the two groups (A and B) identified and constructed the dependencies involved in an equilateral triangle inscribed in another equilateral triangle. We were able to replay the entire sessions of the groups in complete detail, observing all group interaction (text chat and dynamic-geometry actions) that group members observed—for logs and analysis, see (Stahl, 2013, Ch. 7).

Group A went through a collaborative process in which they explored the given figure by varying it visually through the procedure of *dragging* various points and noticing how the figure responded. Some points could move freely; they often caused the other points to readjust. Some points were constrained and could not be moved freely. The group then wondered about the constraints underlying the behavior. They conjectured that certain relationships were maintained by built-in dependencies. Without having figured out the constraints completely, they began trying to *construct* the figure as a way of exploring approaches experimentally using trial and error. Finally, the group figured out how to accomplish the construction of the inscribed equilateral triangles by defining the *dependencies* into their figure using the tools of GeoGebra.

Team B went through a similar process, with differences in the details of their observations and conjectures. Interestingly, Team B made conjectures leading to at least three different construction approaches. Like Group A, they initiated a collaborative process of exploring the given diagram visually with the help of *dragging* points. They developed conjectures about the constraints in the figure and about what dependencies would have to be built into a construction that replicated the inscribed equilateral triangles. They decided to explore trial *constructions* as a way of better understanding the problem and the issues that would arise in different approaches. Eventually, they pursued an approach involving *dependencies* among line segments in the three congruent smaller triangles.

Although both groups reached a similar conclusion, their paths were significantly different. First, they defined their problem differently (Zemel & Koschmann, 2013). Group A focused on listing the constraints that they noticed by dragging points and then on proving that the given triangles were in fact equilateral. Group B, in contrast, quickly realized that it would be difficult to construct triangle DEF to be both inscribed and equilateral, since these characteristics required quite different constraints, which would be hard to impose simultaneously. Whereas Group A coordinated its work so that the members followed a single path of exploration and conjecture, Group B's members each came up with different conjectures and even engaged in some divergent explorative construction on their own before sharing their findings. Despite these differences, both groups collaborated effectively. They listened attentively and responded to each other's comments. They solicited questions and agreement. They generally followed a shared group approach. Together, they reached an accepted conclusion to a difficult problem, which they might not all have been able to solve on their own, illustrating effective group cognition (Stahl, 2006).

The case study of Groups A and B illustrates the approach of collaborative dynamic geometry. The groups took advantage of the three central dimensions of dynamic geometry—dragging, construction and dependencies—to explore the intricacies of a geometric configuration and to reach—as a group—a deep understanding of the relationships within the configuration. They figured out how to construct the diagram and they understood why the construction would work as a result of dependencies that they designed into it.

The inscribed-triangle problem illustrates well the importance of dragging, constructing and dependencies in dynamic geometry. This argues against the current tendency in classroom usage of dynamic geometry software—and in the related research—to emphasize just the dragging. In our log analyses, we can observe clearly the role of all three aspects working together: in Öner's data of the dyad, in our case study of Group A and B as well as in subsequent logs of groups of math teachers collaborating on this problem.

In the Virtual Math Teams Project, we are currently refining the VMT software and developing curriculum (Stahl, 2012b) to guide the use of collaborative dynamic geometry in in-service-teacher professional development and high-school geometry (Stahl, 2012a). The curriculum centers on activities like the one in the case study. The curriculum is closely aligned to the new Common Core State Standards for basic geometry and their recommended mathematical practices (CCSSI, 2011). It covers the most important propositions of Euclid's *Elements*, translating them into research-based, contemporary approaches to geometry and mathematical discourse in a CSCL environment. We will continue to study the results of collaborative dynamic geometry through analysis of the discourse and geometric explorations (Stahl, 2012c). On the basis of a continuing series of trial studies like the one just reported, we feel that the approach of collaborative dynamic geometry can translate the geometry of Euclid into an effective tool of computer-supported collaborative learning.

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An Approach for Supporting Hybrid Learning Communities: The Case of a Regional Parent Community

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Abstract: This paper presents an approach for supporting regionally bound hybrid learning communities combining traditional face-to-face elements with web based media (online community platform, content recommendations, email and SMS newsletters). The main idea behind this approach is to make use of synergy effects based on a tight connection of online and offline aspects. The proposed approach was piloted in the Mobile2Learn project, a regionally bound parent community, in order to motivate and support (especially hard-to-reach underprivileged) parents to educate their young children.

Introduction

Early childhood education lays the basis for later (educational) success. Particularly the education and development of children below three years of age is of tremendous importance (Becker & Becker, 2008). One obvious way to support early childhood education is to directly interact with children, either with or without technology (Yelland, 2005). Another feasible way to improve early childhood education is to motivate, encourage, and support parents to educate their children. Parents have a major influence on the early childhood education of their children since the family is the first and most important education authority in the first years of children's lives (Büchner, 2003). Traditional face-to-face trainings are well established and have shown to be an effective way to educate parents. Here, trainers and trainees know each other, trust can be established, and trainers can adapt to their trainees needs easily. However, those trainings do not scale and are problematic regarding participation of underprivileged parents (Bauer & Bittlingmayer, 2005). With the advent of the social web, several internet online parent communities emerged where parents can get access to educational resources and can also interact with each other. Contrary to local face-to-face trainings, interactive online trainings and platforms scale better, provide a low-threshold access to educational resources, and allow parents to get in contact with each other easily. Nevertheless, most online trainings and platforms are not regionally bound, the users are distributed (thus it is hard for trainers to adapt to parent's needs) and often totally lack professional pedagogic support. Specific research on parent communities is missing – despite the fact that several online parent communities are established (like eltern.de or community.parents.com; with the described shortcomings).

In order to fill this gap, we propose a hybrid community approach which combines the advantages of face-to-face trainings with the advantages of an interactive online platform. In our approach, the online and offline aspects of the community are tightly connected to each other (e.g., via regular email and SMS newsletters informing about local face-to-face events). Our main goal is to show that this hybrid approach is more effective than the two components separately and that synergy effects occur in the sense that face-to-face events promote the online platform and vice versa.

Using community based approaches in educational contexts is, in general, not a new approach. Typical examples of hybrid communities can often be found in school or university scenarios, connected to terms such as "extended classrooms" or "blended learning". In a university context, Harrer et al. (2006) allowed students to use a wiki and discussion boards (in conjunction with a presence lecture) in order to work on group projects. They found that none of the two communication forms proved to be superior, however, a combination produced better results (according to final grades). Also, in a related study of Koch (2003), email notifications and newsletters were found to be a key feature of their community platform.

Mobile2Learn: A Hybrid Community Approach

Mobile2Learn is a small parent community which is based on the proposed hybrid community approach and which focuses on early childhood education topics. The Mobile2Learn project was started by the community college Goslar (an institution for rural parent education) and Clausthal University of Technology. The online community platform was launched in November 2010. As early as this date, users found a small number of 30 articles on that website and the first face-to-face events took place. The project (funding) ended in February 2012. Even though the project was aimed at reaching underprivileged parents, the community website and the face-to-face events were advertised and accessible for all parents without any costs or fees.

The educational activities were structured into six areas (e.g., "learning with all senses", musical education, nature discovery, and "speaking and listening"). For each area (except "nature discovery"), six different regional kindergartens in the district of Goslar were chosen where thematically related events were conducted. All parents were invited to attend (not only parents whose children attend the facility hosting the event). While focusing on parents, the events/trainings were designed in a fashion so that parents could attend along with their children. Goals of the face-to-face events included that parents could get to know each other so that trust could be established, and that trainers could meet the needs of the parents and could get direct feedback.

In addition to the face-to-face events, an online community platform was available (http://www.Mobile2Learn.de). This platform enabled parents to get in into contact with the Mobile2Learn project and community (anonymously) with low threshold. The online platform provided educational articles, photo galleries and interactive quizzes. All articles and photo galleries could be rated with one to five stars (dislike to like) and could be commented on by community members. Forum posts and a few articles were available for reading without registration on the platform to motivate parents to register. A registration in the system was required, however, to access most articles, all photo galleries, user profiles, and to post ratings, comments or forum threads. For registration, users had to enter an e-mail-address, mobile phone number (optional), nickname, date of birth, gender and residence.

Most of the articles and photos on the platform were provided by pedagogues, but it was possible for registered parents to submit their own articles or photos (reviewed by pedagogues before publishing).

Through the hybrid approach, a mutual support of both the online and offline aspects of the community was aimed at: After all events of a thematic area were conducted, photos taken and articles about the contents of these events were put online. As such, parents who participated could look up all contents and also find further information. Moreover, parents who did not attend any events could view the photo galleries and educational resources, thus could getting motivated to attend events in the future. In addition to this material about face-to-face events, the community platform also included a forum and an internal messaging system. This way, parents who had met face-to-face could easily stay in contact with each other online (cf. Haythornthwaite et al. 2000).

A key factor of the online platform was that personalized messages were sent to parents via SMS and e-mail regularly in campaigns. Between April 2011 and February 2012, such messages were sent approximately every other week. These campaigns informed parents about upcoming events, (new) articles or pictures. Also, automatically generated personalized recommendations were included on the homepage (for registered users) and in all e-mail campaigns (cf. Strickroth, 2012). This direct and repetitive way of contacting community members was chosen to continuously and actively "push" information about educational opportunities to parents. This way, parents were regularly reminded that the project still exists and could easily access all new and "interesting" items – we expected this to be a vital factor for the success of this community.

First results and outlook

Our approach was piloted in a field study over more than one year. At the end of the funding period, the total parent community consisted of 505 parents who got into contact with the Mobile2Learn project. 234 of these registered on the online platform (46 %). In total, 182 educational articles (plus 14 articles by partners) and 6 quizzes with 28 questions were created and published on the online platform (as of September 2012). Additionally, 51 photo galleries (one gallery for face-to-face event plus several additional thematic galleries) containing approximately 3000 photos were available on the platform.

Preliminary results allow assuming that using the hybrid approach more parents could be reached. Parents seem to be used to email-newsletters and are quickly reachable using this communication channel. Also there seems to be a strong correlation between campaigns and access peaks on the website. Next steps are to analyze collected usage data and the results of a paper-based questionnaire which was sent to all members of the community.

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Visualization and Elaboration of Students' Group Reading Processes

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Abstract: This study discusses the contribution of data mining of log file data to video and interview data for studying students' collaborative engagement with digital texts presented online. Given that reading is generally an individual activity, understanding this group process is important. Data analyses at multiple levels can reveal group processes of knowledge construction, but can also give conflicting results, particularly related to students' perceptions of the process.

As part of learning through inquiry, students often work in collaborative groups to use multiple digital text resources to follow their own investigation paths while engaging with information. Data mining techniques, such as log file analyses, help to identify diverse navigational styles used to process and integrate multiple sources of information from digital text environments by allowing examination of navigation paths taken by different groups of learners (e.g., Puntambekar, Stylianou, & Hübscher, 2003). But, given that reading is generally an individual activity, understanding group processes of interacting with and making sense of multiple texts during group collaboration is important. Data mining techniques can be used to uncover patterns of navigation through digital systems that are not directly observable (Reimann, Yacef, & Kay, 2011). However, navigation profiles provide only one perspective on groups' processes of information selection and integration. Multiple scales of analysis are important to both understand phenomena at various levels and understand the relationships across scales (Suthers & Medina, 2011). This study discusses the contribution of data mining and visualization of log file data in the form of navigation paths to understanding group processes revealed by other measures, such as group video and interview data. The question addressed is: What processes do students use to construct knowledge from multiple digital texts and how can data mining techniques combined with other data sources increase understanding of these processes?

Procedure

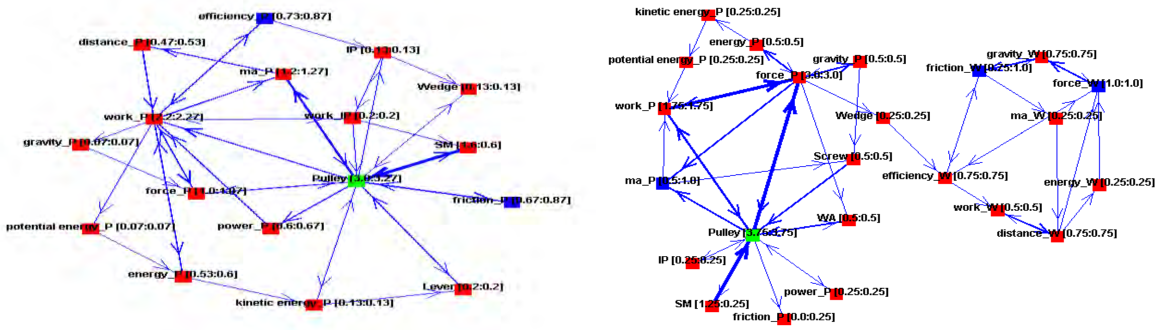
The log file analysis focused on 19 students in a 6th grade science classroom in which students read multiple digital texts using the CoMPASS system (Puntambekar, 2006) as part of a project-based inquiry physics curriculum. CoMPASS helps students engage in inquiry about the physics related to multiple topics, such as simple machines, and provides navigable concept maps designed to mirror the conceptual structure in the domain of physics and help students gain a rich understanding of concepts and relationships. CoMPASS provides two representations: a navigable concept map and textual descriptions. The concept that is being read about becomes the focal point of the map and the other concepts move accordingly based on the strength of their relationship to the concept of focus.

Navigation log files were used to look at the students' navigation behavior while using CoMPASS for approximately 15 minutes to learn about physics concepts to help them with the challenge of lifting a water bottle off of a table with the least amount of force. The topics and concepts that students visited and the time spent on each were recorded in chronological order. The log files were later used to develop navigation profiles to help understand students' meaning making processes while using CoMPASS by making students' navigation choices visible. In another iteration of the physics curriculum, video was collected of students' group interactions with CoMPASS in order to investigate their processes of interacting with the texts and making navigation decisions. Further, five student small groups (N=4 in each group) were interviewed at the end of the curriculum to examine students' reasoning behind their group's interactions with the texts and whether their perceptions of their processes for selecting concepts align with the analyses of strategies from the video data and the previous navigation profiles developed from the log file data.

Analysis and Findings

The log files of students' interactions with CoMPASS were analyzed using Pathfinder (Schvaneveldt, 1990). Pathfinder is a graph theoretic technique used to create network representations consisting of nodes and links that characterize navigation patterns in CoMPASS, allowing us to look at similarities and differences in navigation paths. Navigation patterns (see Figure 1) show the number of times students "navigated to" a concept and the number of times students "navigated from" a concept and from which concepts students navigated to others.

The log file data reveal distinct ways in which students structured their paths through information presented in the CoMPASS system. For example, two clusters that were found highlight the differences between students who focused on concepts within a single topic versus those who chose to explore concepts in multiple topics. Cluster 1 (N=15) reveals that students investigated how all of the concepts within pulley may apply to the challenge and also looked at the topics of other simple machines. However, students did not look at any concepts within these other machines. Cluster 2 (N=4) reveals that students explored all concepts within pulley with regard to their challenge as well as many of those same concepts and how they apply in a wedge.



Cluster 1 **Cluster 2**

Figure 1. Navigation patterns of the two clusters. Each node has the name of the concept and the topic, so work_P means students visited the concept of work in the topic pulleys.

From the log data, it appears that students in Cluster 1 were relatively goal-focused in their navigation. Log file data for Cluster 2 revealed search processes that appear to be less focused. However, the analysis of the video data revealed that log file data only captures the navigation preferences of a subset of students when working in collaborative groups. Students struggled at times to take up and consider all navigation suggestions, and some students tended to be deferred to more than others. Despite these collaboration issues revealed by the video data, in the interview data, students often perceived their group processes as conducive to conducting research related to their goal. Students also reported that they were able to use the concept maps to focus on content, but the navigation profiles indicate that students' navigation behaviors are not always goal-focused.

The multiple forms of data used for this study provide different perspectives on students' processes of interacting with multiple texts. The analyses also give insight into how the use of multiple data sources can shed light on the importance of different levels and scales of analysis and interpretation when studying engagement with multiple digital texts. Of particular concern is that, despite the issues revealed by the navigation profiles and video data, students perceived their processes for engaging with multiple texts as a collaborative group as productive and goal-focused overall. Kulikowich & Young (2001) have argued for making the collaboration process visible to learners in order to enhance their performance. This study underscores the need for investigating collaboration at multiple levels to not only inform understanding of the collaborative process for researchers and teachers but also to collect information for learners to help them understand their processes of navigation and collaboration. Perhaps, allowing collaborative reflection on navigation profiles may help students to make productive navigation choices.

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Improving Academic Essays by Writing and Reading Peer Annotations on Source Documents

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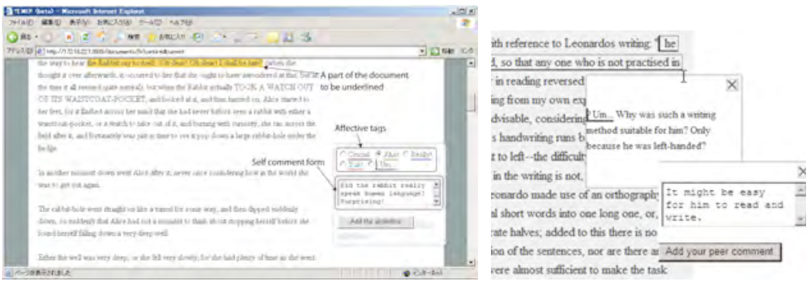
Abstract: We attempted to improve written arguments made by undergraduate learners of academic writing based on their intuitive and affective response to reading peer comments on source documents. To do so, we developed and utilized a previously developed CSCL environment called EMU (emotional and motivational underliner) for the addition, provision and review of annotations. The analysis of the learners' use of EMU implied that learners who wrote good essays tended to focus on annotations that used affective tags to express negative, sceptical and surprised attitudes toward the document, as opposed to comments in general; in contrast, low-scoring writers tended to apply equal attention to all comments.

Introduction

The aim of the present study was to examine whether reading and writing peer comments on research documents acting as sources for academic essays (in other words, annotating those documents and reviewing annotations) promotes the development of students' writing in their argumentative essays. When students write essays, they review related documents, come to understand relevant issues, and produce positive or negative opinions toward arguments made in the documents. Then, they plan what and how to construct an argument.

Intervention in this process can potentially help students write better essays. To explore this possibility, Suzuki & Suzuki (2011) developed a Web-based collaborative environment, EMU (emotional and motivational underliner). The left side of Figure 1 shows a screenshot of EMU. The system provides students with a document to be reviewed. Students can freely underline and comment using affective tags (seen at the right of Figure 1). These tags were designed to naturally extract students' initial ideas when reading the material, and they have been found effective for students' own purposes in writing academic essays (Suzuki & Suzuki, 2011). These annotations are not only shared with peers, but can also be commented on by them. The centre of Figure 1 shows the input form for peer comments. The system provides many means for students to enhance their writing: externalizing their own ideas (Shirouzu, Miyake, & Masukawa, 2002), encountering different ideas, comparing others' ideas with their own, and providing comments on others' ideas (Cho & MacArthur, 2011).

We introduced EMU to an undergraduate academic writing class and analysed the access log to explore the relationship between the use of the system and the quality of the essays composed after the activity.



Really! Add this when you want to say "Really, that's right," or "Good!" (blue).
Aha! Add this when you want to say "I haven't realized this," or "It's great!" (green).
Yuk! Add this when you want to say "Hey, that's wrong," or "It's awful!" (red).
Um... Add this when you want to say "You bet?" or "I don't get it" (black with "?,").
Crucial. Add this when you want to say "This part is crucial" (black).

Figure 1. EMU (left), input form for the peer comment (centre), and affective tags on EMU (right).

Analysis

We analysed data from a class of 28 students learning academic writing. First, they read a document, and underline and gave 'self-comments' or SCs. Next, they read through others' SCs and commented on them ('peer comments' or PCs). Finally, they composed an essay on the material.

The essays were rated on a five-point scale (*1*: *poor* to *5*: *excellent*) by the authors themselves independently. Since the scores were highly correlated (Pearson's r=.67, $t(24)$=4.41, p<.001), we averaged these scores and divided the students into high-score (HS: n=12) and low-score (LS: n=10) groups by the median (3.0). Four students, whose score was exactly 3.0, were excluded from the analysis. We then examined differences in EMU usage between groups.

Results and Discussion

In all, the students produced 315 SCs and 1,164 PCs for others' SCs. Two judges, who did not know the aim of the study, classified the SCs (correspondence rate: 95%) and PCs (correspondence rate: 90%) according to the following categories:

SCP (self-comment: pro) Comments that agreed with or were surprised by the content of the document.

SCC (self-comment: con) Comments that disagreed with the document or wondered about the underlined content.

PCP (peer comment: pro) Comments that agreed with or were surprised by others' SCs.

PCC (peer comment: con) Comments that disagreed with or wondered about the content of others' SCs.

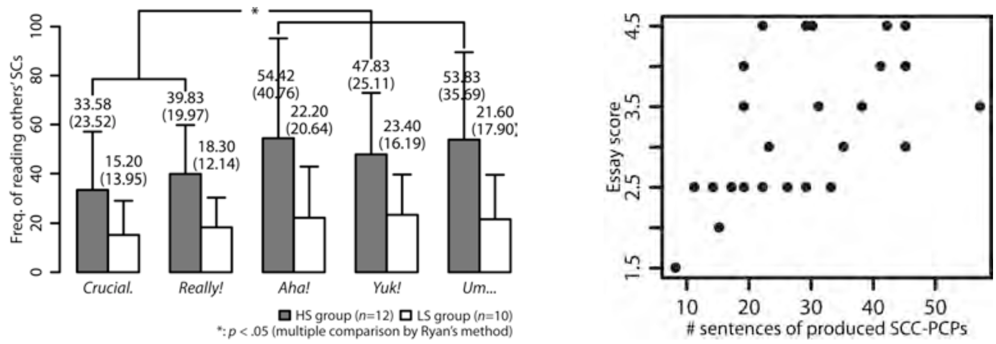


Figure 2. Frequency with which students read others' SCs by group and tag (left) and correlation between the number of sentences contained in the produced SCC-PCPs and essay scores (right).

The left side of Figure 2 shows the frequency with which students read others' SCs by group and affective tags. While students in the LS group tended to read others' SCs regardless of the affective tags, students in the HS group seemed to read the comments with 'Aha!' 'Yuk!' and 'Um…' tags more frequently than other tags. This tendency was statistically significant.

A distinct difference was observed in the number of PCPs toward SCCs (SCC-PCPs) between the HS and LS groups. Thus, we examined the correlation between students' essay score and number of sentences of produced SCC-PCPs, including the data of the students excluded above. The right side of Figure 2 is a scatter plot of this analysis, showing a positive significant correlation between SCC-PCP sentences and essay score (Pearson's r=.53, $t(24)$=3.09, p<.01). This result implies that HS learners mainly focus on the SCs of others that show a negative attitude toward the document, and that they tend to add PCs that support such SCs.

Thus, the results show that HS learners tend to read others' SCs with affective tags such as 'Aha!' 'Yuk!' and 'Um…' more frequently than do LS learners. Moreover, HS learners tend to elaborate their own ideas by producing PCs commenting on others' SCs rather than just reading PCs from other learners. This implies that high-performance learners focus strategically on finding and evaluating issues in the documents as part of their problem-finding process.

In past research (Cho & MacArthur, 2011), in peer reviews of each other's paper drafts, learners who pointed out many problems and suggested many ideas for improvement of the drafts tended to compose a high-quality paper. These past findings and the results of the present study suggest that the ability to detect problems and suggest alternatives may be crucial skills in various phases of the academic writing process. By exploring the learning process of academic writing by high-performance learners in a CSCL environment, taking into account human cognitive mechanisms and the role of collaboration, we should be better able to improve the collaborative learning environment of academic writing and enable learners to compose essays that employ these learning techniques.

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Extending Inquiry: Collaborative Learning with Immersive, Interactive Projection

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Abstract: We report two studies that highlight how immersive, interactive projection technology supported collaborative STEM inquiry learning. The immersive experience was brief (15 minutes) but inquiry extended well beyond. In study 1, this extension was provoked by a student noticing a pattern and leading the class to derive a formula. In study 2, students graphed data from the dome, provoking questions about superficially-understood phenomena. We found pairing immersive, interactive projection with problem-based lessons provoked generative learning.

Major issues addressed and potential significance

Engaging and inspiring *all* students to participate in STEM learning is a major challenge; with new standards focused on STEM *practices*, our understanding of how to support all learners is limited. Our research investigates the potential of immersive, interactive projection to support inquiry. Our research team has the capacity to develop low-cost immersive, interactive projection kits for use in classrooms. We are interested in considering how our designs can transform corners of classrooms into the Rings of Saturn, carbon nanotubes, field trips to the Devonian, etc., providing collaborative contexts for inquiry learning. In this paper, we present results from two pilot studies, which sought to explore how immersive, interactive technology (Figure 1) might provide context for inquiry teaching and learning. To achieve these objectives, we are developing technology, codesigning projects with teachers, and studying implementations and student learning. We are investigating, in what ways might an immersive experience provide a context for inquiry learning, before, during, and after the experience? We explore the design affordances for using immersive projection to support collaborative inquiry. The focus of this paper is to compare two designs that were tested. Virtual learning environments enhance learning when they offer a situated experience (Dede, 2009), which is an effective inquiry approach (Rivet & Krajcik, 2008). Although little research has explored the use of immersive projection technologies for learning (Apostolellis & Daradoumis, 2010), studies have found benefits for viewing immersive displays in terms of recall (e.g., Sumners, Reiff, & Weber, 2008). Open questions about the role of immersive environments for learning remain; in particular, Dede (2009) highlights that research is needed on supporting transfer by blending learning across virtual and real settings. We explore how learners proceeded through real and projected settings.

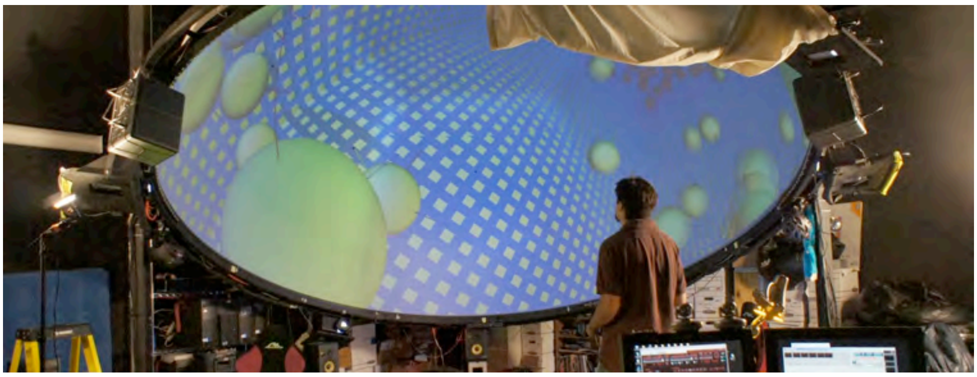

Figure 1. Our dome can accommodate about 12 people. Novel control devices allow for interactivity.

Methodological approach

These studies use a design-based approach (The Design-Based Research Collective, 2003), leveraging findings for refinements to the inquiry lessons and technology, and leading to design guidelines for supporting inquiry with immersive technology. This project brings together expertise in computer science, mathematics, science, teacher education, and learning sciences. We examine learning through interaction analysis (Jordan & Henderson, 1995) and as evidenced in assessments and artifacts. Two teachers (co-authors MD and NK) were recruited to design and implement highly-scaffolded problem-based lessons incorporating immersive, interactive media. Mr. Dahlgren co-designed a lesson on arithmetic and geometric sequences with a narrative context of asteroids threatening to destroy all life on Earth; *DomeStroids* (DS) allows users to navigate through space with a skateboard and use the Wii-mote to blow up asteroids into a pre-specified number of pieces. Mr. Kvam co-designed a lesson that used a short version of a previously tested unit on Global Climate Change (Svihla & Linn, 2012). *ClimateDome* (CD) was used to reinforce understanding of the greenhouse effect, allowing the users to control the level of CO_2 with the Wii-mote, and then export data. In both cases, students took on roles (e.g., pilot, asteroid spotter, model engineer, CO_2 specialist). Participants included pre-service elementary teachers (DS, n=9) and pre-service secondary science teachers (CD, n=8). In both studies, students completed a 60 minute pre-dome activity that introduced a challenge; they began solving related problems. The dome session involved 15 minutes of immersive, interactive projection and additional 40 minutes of collaborative problem solving. A post-dome session involved whole class discussion.

Findings and Implications

In both studies, student work shows evidence of learning; whereas previously, only 10% of students developed understanding of sequences, in this case, 66% of students reached a medium or high level of understanding of sequences using *DomeStroids*; on the pretest, half of the students provided a normative explanation of the greenhouse effect, but after using *ClimateDome*, all students provided a detailed, normative explanation.

In *DomeStroids*, Mr. D guided students with prompts that helped them to notice specific details, such as how many strikes it took to break the asteroids up into small enough pieces, or how many pieces resulted from each strike. We observed a transition point when Ignacio - a student who rarely participated in class and who struggled with the math content --answered one of Mr. D's questions by posing his own question about whether there would "be a formula" for what they were seeing. We see this as a critical moment for two reasons: 1) it marks a change from Mr. D primarily asking procedural questions to primarily prompting the students to help each other; and 2) Ignacio engaged the class more deeply with the math and led them to write an abstract formula. We conjecture that the activity in the dome was different enough from school experience that it may have enabled connections to informal experiences (such as video game play), allowing a student to find purchase on an activity that – had it been conducted in a more traditional manner—he may not have.

Students returned from *ClimateDome* with data sets exported from their experiments in the dome; they explored these data during class, constructing graphs. They struggled to interpret them, provoking numerous questions and discussion about how variables related to one another (e.g., why did infrared radiation increase when the level of CO_2 was increased?). In prior experiences with the non-immersive version, when a teacher projected a visualization, student learning was typically narrow and worse (as compared to allowing student pairs to interact with the visualizations on their own). In this case, there may be an advantage for the immersive component, which affords pointing and gesturing by all present, and supporting the development of shared understanding.

While our studies are exploratory and findings tentative, we can report that the dome sessions engaged students and supported learning beyond the brief immersive, interactive experience. Although the problem-based lessons were designed with a high degree of scaffolding, students engaged in a more generative manner.

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Scripting and orchestration of collaborative inquiry: An increasing complexity of designs

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Abstract: The emergence of increasingly social and connected technologies is providing new opportunities for computer supported collaborative learning designs, (e.g., user-contributed content, tangible and embodied interactions, and augmented reality), while raising challenges and complexities in the scripting and orchestrating of these interactions. This poster responds to these challenges, introducing an orchestration framework (S3) within the context of two grade 11 physics classes in a smart classroom setting.

As CSCL interventions become increasingly complex in terms of the interactions we require between students, teachers, materials, and the learning environments, there is a growing need to structure these interactions in the form of pedagogical scripts (Dillenbourg & Jermann, 2007). Further, with the increasing complexity and duration of our CSCL scripts, there is greater need to give teachers the information and tools to orchestrate their enactment – even as they may unfold "on-the-fly" (i.e, requiring real-time decisions). Orchestration is achieved through direct social interactions as well as through technological supports. In response, we are developing SAIL Smart Space (S3), an open source framework that coordinates complex pedagogical sequences, including dynamic sorting and grouping of students, and the delivery of materials based on emergent semantic connections (Tissenbaum & Slotta, 2012).

To inform our development of the S3 intelligent agent framework, we developed PLACE.web (Physics Learning Across Contexts and Environments) a 13-week high school physics curriculum where students capture examples of physics in the world around them (through pictures, videos, or open narratives), which they explain, tag, and upload to a shared social space. Within this knowledge community, peers are free to respond, debate, and vote on the ideas submitted by their peers. Driven by the KCI Model the goal of PLACE.Web is to create an environment where the class' collective knowledge base is ubiquitously accessible - allowing students to engage with the ideas of their peers spontaneously and across multiple contexts. We will focus on the culminating activity, which occurred across three contexts, employed user contributed materials, leveraged the spatial aspects of the room, and used intelligent agents in a consequential way.

Culminating Smart Classroom Activity

The curriculum culminated in a one-week activity where students solved ill-structured physics problems based on excerpts from Hollywood films. The script for this activity consisted of three phases: (1) at home solving and tagging of physics problems; (2) in-class sorting and consensus; and (3) smart classroom activity.

In the smart classroom, students were heavily scripted and scaffolded to solve a series of ill-structured physics problems using Hollywood movie clips as their domain (i.e., could IronMan Survive a shown fall). Four videos were presented to students, with the room physically mapped into quadrants (one for each video). The activity was broken up into four stages: (1) Principle Tagging; (2) Principle Negotiation and Problem Assignment; (3) Equation Assignment, and Assumption and Variable Development; and (4) Solving and Recording. In each step students moved, or were sorted, within the room completing a set of collective and collaborative tasks that built upon the emerging knowledge base, using their tablets or large format interactive displays. During the acidity the teacher used a set of specially designed feedback technologies to aid in its orchestration.

Orchestration of the culminating script:

Ambient Feedback: A large Smartboard screen at the front of the room (i.e, not one of the 4 Hollywood video stations) provided a persistent, passive representation of the state of individual, small group, and whole class progression through each step of the smart classroom activity. This display showed and dynamically updated all student location assignments within the room, and tracked the timing of each activity, using three color codes (a large color band around the whole board that reflected how much time was remaining): "green" (plenty of time remaining), "yellow" (try to finish up soon), and "red" (you should be finished now).

Scaffolded Inquiry Tools and Materials: In order for students to effectively engage in the activity and with peers, there is a need for specific scaffolding tools and interfaces for students to interact, build consensus, and generate ideas as a knowledge community (i.e., personal tablets, interactive whiteboards). Two tools were provided to students, depending on their place in the script: individual tablets tied to their S3 user accounts; and four large format interactive displays that situated the context (i.e., the Hollywood video), providing location specific aggregates of student work, and served as the primary interface for collaborative negotiation

Real-Time Data Mining and Intelligent Agency: To orchestrate the complex flow of materials and students within the room, a set of intelligent agents were developed. The agents, programmed as active software routines, responded to emergent patterns in the data, making orchestration decisions "on-the-fly," and providing teachers and students with timely information. Three agents in particular were developed: (1) The Sorting agent sorted students into groups and assigned room locations. The sorting was based on emergent patterns during enactment; (2) The Consensus Agent monitored groups requiring consensus to be achieved before progression to the next step; (3) The Bucket Agent coordinated the distribution of materials to ensure all members of a group received an equal but unique set of materials (i.e., problems and equations in Steps 2 & 3).

Locational and Physical Dependencies: Specific inquiry objects and materials could be mapped to the physical space itself (i.e., where different locations could have context specific materials, simulations, or interactions), allowing for unique but interconnected interactions within the smart classroom. Students "logged into" one of four spaces in our room (one for each video), and their actions, such as "flinging" a tag, appeared on that location's collaborative display. Students' location within the room also influenced the materials that were sent to their tablet. In Step 2, students were provided with physics problems based on the tags that had been assigned to their video wall, and in Step 3 they were provided with equations based on their consensus about problems in Step 2.

Teacher Orchestration: The teacher plays a vital role in the enactment of such a complex curriculum. Thus, it is critical to provide him or her with timely information and tools with which to understand the state of the class and properly control the progression of the script. We provided the teacher with an "orchestration tablet" that updated him in real-time on individual groups' progress within each activity. Using his tablet, the teacher also controlled when students were re-sorted – i.e., when the script moved on to the next step. During Step 3, the teacher was alerted on his tablet whenever a group had submitted their work (variables and assumptions)

Analysis and findings from the smart classroom run:

Ambient Feedback: Analysis of the captured video seems to indicate the ambient display was effective for both students and teacher in orchestrating the flow of classroom activities. During the activity the teacher looked at the front ambient display sixteen times. This was often followed by an orchestrational statement, (i.e., telling students to finish up an activity), or an orchestrational move (i.e., advancing the class to the next step). In the post-interview the teacher noted that he would only glance at the display when he wanted a quick update and otherwise ignored it, highlighting the effectiveness of the display for occupying the periphery of awareness until needed. He also noted that the display was very effective in organizing the flow of students and activities as "it let the kids know what group to get to, and it just resolved it quicker to get back to they physics of the moment, I didn't have to spend a lot of time organizing."

Real-time Data Mining and Intelligent Agency: An examination of the server logs showed that the S3 agents effectively managed the distribution of students and materials as per their design. For example, the sorting agents tracked the number of tags assigned to each board by students in Step 1, and regrouped students based on tagging frequency, successfully placing students at new boards with new members in a complex, dynamic re-sorting. The consensus agent also worked as designed, requiring students to reach agreement before moving to the next step and alerting the teacher on his tablet at the end of Step 3 to review group work. The bucket agents also successfully delivered location specific and context-filtered content, providing students with one physics at a time, drawing from a "bucket" of items that were only determined after the principles were settled.

Locational and Physical Dependencies: Both the locational and physical dependencies worked as designed in the intervention. When students logged into a location all their interactions were properly situated within that space. Student contributions and location specific materials were correctly sent between student tablets and the boards and aggregated with the work of others (see agents above). The physical layout of the smart classroom was also proved to be a powerful tool in the enactment of the activity. By placing the interactions around the edge of the classroom not only were videos (contexts) clearly separated, but also the teacher found it useful for orchestrating the activity as placing "the kids on the outskirts" left him "free to wander in the middle."

Teacher Orchestration: The teacher was able to use his orchestration tablet to move the students through all the steps in the activity. Analysis of the video highlighted that the teacher often used the tablet in conjunction with an orchestrational statement, such as instructing the students to watch the ambient display, or to explain what would be happening next (see timeline). In the post-interview the teacher noted that although he found the tablet useful for seeing student progression he actually preferred the ambient and large format displays for this purpose as he found with the tablet he tended to have his head down too much whereas the screens were "large and easily accessible" allowing him to take a read of the class at a glance to decide who to help.

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Motivated Interactions with Digital Games in a Science Center

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Abstract: There is untapped value in adopting motivation theories to inform the design of educational technology. Achievement goal theory explains why students whose primary aim is to learn and understand (mastery goal) think and act differently from those who focus mostly on competition (performance goal). We use self-reports to identify students with different motivational patterns and video analyses to understand how learners' motivational profiles relate to their interactions with a digital science game with hands-on features.

Introduction

Decades of research point to the crucial role of motivation in students' engagement and learning, suggesting that deep and continuous learning does not depend only on amount of engagement but reason for engagement (Schunk, Pintrich & Meece, 2007). For example, learners can be motivated by their desire for content mastery, for personal progress, and for outperforming others. Using a mixed-methods approach, we look at how motivation relates to visitors' interactions with digital games in a collaborative science center setting. Specifically, our research question is as follow: How are learners' motivational profiles related to how they interact with each other and with digital media artifacts in the science center?

Though research on motivational theories and their applications to education has generated thousands of journal articles, there is relatively little empirical evidence about whether these theories also hold up in educational technology settings. We highlight the achievement goal theory (Dweck & Leggett, 1988) of motivation to offer researchers, educators, and designers useful and theoretically-grounded constructs that can be empirically studied in digital media learning contexts. Achievement goals reflect both the reasons why an individual is motivated, as well as the standard against which they judge their success—and these reasons have different cognitive, affective, and behavioral implications. Researchers have distinguished two achievement goal orientations toward learning: mastery and performance. A mastery goal focuses on developing and mastering skills and knowledge whereas a performance goal focuses on appearing competent such as by outperforming others or by avoiding appearing incompetent (Anderman & Wolters, 2006). Empirical evidence suggests that adopting mastery goals has positive effects, including increased cognitive engagement in learning, deeper cognitive strategies, and greater interest in the task (Dweck & Leggett, 1988). The literature for performance goals has been less clear, with research indicating that the important distinction is whether students adopt the approach form of focusing on appearing highly competent or the avoid form of focusing on not appearing to be the least competent in a group. Furthermore, these goals can be complementary, as a learner can be both high in mastery and performance-approach goals. Much of the research on achievement goals has been conducted in classrooms or research labs, and we extend this work by examining implications of such goals in the context of an out-of-school digital media environment.

Study Design and Analyses

Task: Heat Pump Game

The heat pump exhibit used in this study is part of a larger exhibition about energy of the future at the Norwegian Museum of Science and Technology. The exhibition resembles a carnival with game booths about sources of energy such as sun, wind, and ocean waves. The heat pump game, designed and produced by our research lab, teaches students about energy transfer and the relation among pressure, condensation, evaporation, and temperature. Players learn about the general function of a heat pump—that it moves heat from inside to outside and vice versa—on the start screen before being shown a screen of the zoomed-in heat pump with details of its inner workings. Players are challenged to keep the house temperature consistently warm throughout the year by operating the heat pump through physically rotating a metal crank using the appropriate speed and direction. Two metal handprints on the table change temperature to align with the movement of heat in the simulation. As such, students operate the heat pump compressor using the physical crank to heat up or cool down the house as the heat pump's inner workings dynamically move in real time on the screen. The result screen following the game shows the percentage of time the house stayed within the desirable zone of warmth as well as the amount of energy saved.

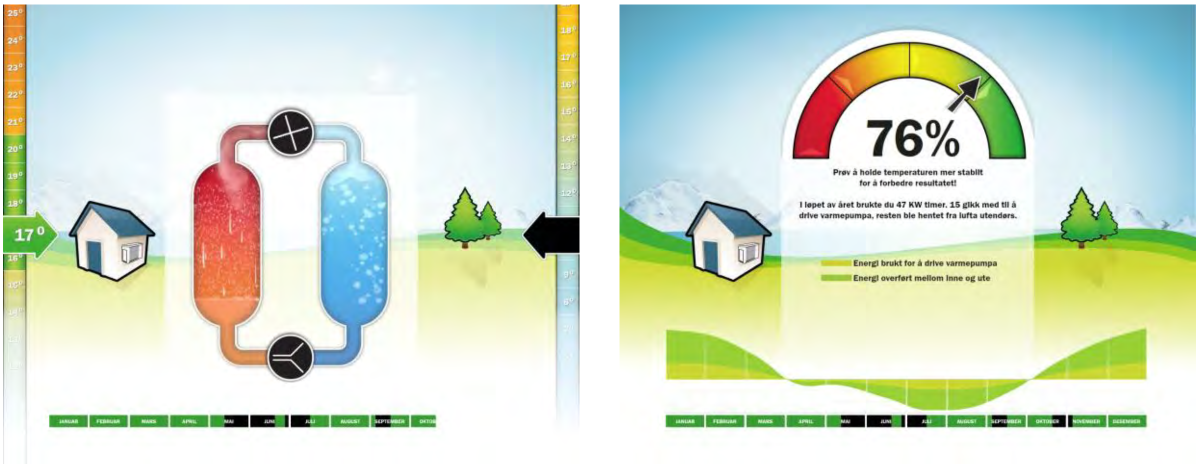

Figure 1. Screenshots of the heat pump game during the play (left) and of the results screen at the end (right).

Preliminary Analyses

For our heat pump game, we administered self-report measures of achievement goals to identify high school students with different motivational profiles, as indicated by their reported levels of mastery, performance-approach, and performance-avoid goals. The self-report items that measured mastery, performance-approach, and performance-avoid goal orientations were adapted from the Patterns of Adaptive Learning Survey (www.umich.edu/~pals/manuals.html). All three goal orientation constructs were scored on a 7-point Likert scale ranging from 1 (not at all true for me) to 7 (very true for me). Mastery goals focused on learning and understanding (e.g., "My goal is to learn as much as I can"); performance-approach goals focused on demonstrating ability and outperforming others (e.g., "My goal is to look smarter than other students"); and performance- avoid goals focused on not looking dumb (e.g., "My goal is to avoid looking like I can't understand the material"). Individual items in the specific goal constructs were averaged to create a final score from 1-7. This allowed us to select students of different motivational types, during a classroom field trip, for video-based analysis of their interactions with the exhibit to complement the quantitative accounts of their motivation. Our preliminary analyses show differences in the ways students attend to different parts of the screens such as the temperature meter, the scientific simulation, and the point screen. These choices are related to their motivation as well as levels of higher-order thinking, help-seeking behaviors, and responses to questions that press for deeper understanding.

Implications: Theoretical and Practical

Our research illustrates how the same event may have entirely different impacts on motivation and learning depending on the goals students bring to an activity. In doing so, we extend the current theoretical literature on achievement goals by providing specific examples of the process by which this may happen in the context of game-based learning. On a practical level, understanding how certain game elements afford different types of interaction for students with different motivations can provide insights about how to design game environments that promote adaptive motivation and effective learning.

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Learning Across Space, Time, and Scale: A Bayesian Perspective

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Abstract: Theories of causal inference and pattern recognition based on machine learning have been proposed as normative models of human learning. To date, these theories fail to include explanations for why humans are biased towards some types of data (such as surprising or confirming) over others. In this poster we will provide a novel explanation for this, and use this hybrid theory to highlight areas of prior CSCL research that successfully supported student learning across space, time, and scale, as well as propose future research.

Introduction

Humans of all ages frequently make rapid causal inferences based on covariational information. In simple settings, when effects and probable causes are well defined, this process is relatively efficient. For example, assume that you own a cat with a particularly weak constitution. One day, said cat eats some food that you drop on the ground and later becomes ill. Does that cat have a virus, or do you presume that its current condition is the result of its having eaten some of your lunch? Normative theories of causal inference predict that you will use relative prior information about your cat (such as how frequently it gets ill after eating your food vice how frequently it is sick with a viral information) to make a decision about taking it to the vet. In this poster, we will give a brief overview of these theories of human causal inference, and then combine them in a novel way with theories of information processing from computer science in order to propose best practices and future strands of CSCL research regarding causal learning across space, time, and scale.

Background

Causal Bayes Nets

Developmental psychologists and cognitive scientists have long endeavored to quantify and predict human causal inference. Early models were based on relative frequencies (i.e. covariation) of candidate events and causes (Jenkins & Ward, 1965). Eventually, these equations were modified to encompass measures of causal strength as well (Cheng, 1997). These models were limited in the assumptions they made about cause-effect relationships, however. Glymour (1998) re-framed Cheng's (1997) theory as a type of graphical analysis known as a Causal Bayes Net (CBN). Based on the work of Pearl (1988) the CBN theory of human causal inference posits that, given well defined inputs, humans will make simple causal inferences in a normative manner. We can use the scenario in the introduction, above, as an example (Figure 1, below).

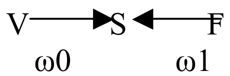

Figure 1. Causal Bayes Net depicting the causal effect of a virus (V) and/or food (F) on your cat being sick (S) (ω0 and ω1 represent the strength of the observed causal connections.)

Observing Figure 1, above, we note that a directed edge (arrow) goes from V to S and from F to S, indicating that both V and F are independent causes of S. In addition, we note that each causal relationship has an associated weight (ω) that indicates the strength of the proposed connection, based on observation of covariation. In the scenario above, you would be likely to "screen off" V as a potential cause if the strength of the relationship between F and S was historically stronger. This highlights two points: 1) humans may infer simple causal relationships in a manner consistent with CBNs, and 2) this inferential process may prohibit humans from identifying complex causal relationships (Grotzer & Tutwiler, in preparation).

Researchers over the last decade have used CBN-based theories to model and predict human causal inference across different tasks and ages (e.g. Schulz & Gopnick, 2004; Griffiths &Tenenbaum, 2005). These studies all focus on learning simple relationships, however, and for good reason. The developers of CBN methods (Pearl, 1988, 2000), have shown that computation of CBNs become intractable as systems become more complex (Bishop, 2006). If the core cognitive mechanism used to infer causal connections may force people to form overly simplistic causal models, and that the mechanism can't be scaled up directly to infer more complex models, how does this theoretical framework help us to positively impact student causal (or systems) learning?

Information Theory

One way to help support student understanding of complex systems, assuming a CBN paradigm, is through the application of information theory. The degree of surprise in learning some piece of data "x" is defined as *information*, and is given in column 1 of Table 1, below. In essence, the higher the information level some piece of data has, the more likely one is to use that data in the causal weights (ω) defined above. The *amount* of information you have to transmit in order for "x" to be used in the updating of your update beliefs is said to be the *entropy*, and is given in column two of Table 1, below. In general, entropy increases as distributions become more broad and uninformative. In other words, if students are exposed to data that they already expect (*or that they don't know not to expect*), then it takes *much* more data to override a prior belief. Finally, we also consider the relative entropy (Table 1, Column 3), or the average addition information required to transmit a value (x) if we assume a distribution, q(x), which is not exactly the same as the distribution actually generating the data, p(x). In other words, if the student has the wrong model in mind, the amount of extra information, on average, that they have to gather before they correctly discern the value of x, which can then be used to update their prior belief, is the *relative entropy*. In essence, the *amount of information needed becomes much greater as p(x) and q(x) diverge.*

Table 1. Data information, entropy, and relative entropy equations

Information	**Entropy**	**Relative Entropy**
$h(x) = -\ln p(x)$	$H[x] = -\sum_{x} p(x) \ln p(x)$	$KL(p\|\|q) = -\int p(x) \ln\{\frac{q(x)}{p(x)}\} dx$

Bayesian Updating

The updating of causal weights with new data described above can be framed in terms of belief change using Bayes' Theorem: P(ω|D) = P(D|ω)P(ω)/P(D)

In effect, your belief in the strength of a relationship, given new data, is proportional to your prior belief in that relationship and the likelihood of that new data. If the data is high information (surprising, or low entropy) or if your mental model closely aligns with the process that is generating the data, then you will be more likely to update your belief, which will then impact the model (CBN) you use to evaluate future data.

A CBN/IT Perspective of CSCL

Assuming that students make causal inferences in ways consistent with CBN theories, weigh information in ways consistent with Information Theory, and generally update prior beliefs in a Bayesian manner, then certain best practices can be recommended. In our poster, we highlight examples from prior CSCL research in which data Information, Entropy, and Relative Entropy were properly leveraged to maximize causal (or systems) learning across instances of space, time, and scale. These examples include studies of a multi-user virtual environment (Metcalf et al, 2011), hypermedia (Liu & Hmelo-Silver, 2009), and role-play (Deaton & Cook, 2012). The theoretical contributions from this poster should help to inform future research on causal and systems learning research, and should be of great benefit to the CSCL community.

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Enhancing Pre-Service History Teachers' Historical Reasoning Through a Computer-Supported Collaboration Script

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Abstract: The study focusses on the use of collaboration scripts to support pre-service history teachers' historical reasoning. 18 student dyads collaborated on a historical inquiry activity, based on several historical sources. Al dyads were guided by a collaboration script sequencing activities, but half of them received additional support to stimulate argumentation. Preliminary findings regarding the impact on students' interaction, quality of argumentation and domain-specific knowledge will be presented at the conference.

Introduction

Research on history learning has consistently emphasized that students should not only gain insight into the past, but must also come to understand the methods historians use and be able to reason about historical evidence. These competences can be acquired through historical inquiry, which requires students to integrate information about the past from a variety of sources in order to present their own account of the past (Van Drie & Van Boxtel, 2008; VanSledright & Limón, 2006). The process of reasoning with information about the past is generally described as *historical reasoning* (Monte-Sano, 2010). According to Van Drie and Van Boxtel (2008), it generally includes one or more of the following components: asking historical questions, analyzing sources, situating phenomena in context, forming arguments, using substantive concepts and/or using meta-concepts. Previous findings confirm that an engagement in historical reasoning promotes students' understanding of how historical knowledge is attained, and also increases students' knowledge and recall of the historical phenomena which they studied (VanSledright & Limón, 2006).

Although students cannot be expected to handle information in an experts' manner, they should nevertheless learn to adopt an analyzed approach when handling source information (Perfetti, Britt, Rouet, Georgi, & Mason, 1994). However, this can be very demanding of students, as historical reasoning is a complex process (Van Drie & Van Boxtel, 2008). Spoehr and Spoehr (1994) argue that *argumentation* in particular is the most difficult aspect of historical reasoning. Forming a historical argument is not the same as simply giving one's point of view, as a claim is worth little without evidence to support it (Monte-Sano, 2010). Within the domain of history, argumentation is largely a process of informal reasoning, which means that evidence and arguments have to be weighed against each other to form a conclusion that is never definite, but more or less probable (Voss, Perkings, & Segal, 1991). Previous research confirms that this particular aspect of argumentation in history poses a challenge to students. It was found that students generally present several arguments in support of their claim, but rarely consider counterarguments or weigh arguments pro and contra (Van Drie, Van Boxtel, Jaspers, & Kanselaar, 2005).

Van Drie (2005) states that collaborative reasoning tasks can elicit processes that enhance historical reasoning and the learning of history, as discussion leads to higher-level historical reasoning. Therefore, *computer-supported collaboration scripts* seem a fitting approach to support historical reasoning. Collaboration scripts consist of a set of guidelines describing how students have to collaborate (Dillenbourg & Jermann, 2007). According to Kollar, Fischer and Slotta (2007), collaboration scripts are particularly suited for open-structured inquiry activities, such as the ones in history, where a lack of specific instruction may be detrimental to the learning process. Previous research has demonstrated how a collaboration script can prescribe approaches for dealing with the task that a student wouldn't spontaneously engage in (Weinberger, Ertl, Fischer, & Mandl, 2005). Therefore, the aim of this study is to examine whether a collaboration script can to stimulate students' argumentation during historical inquiry activities.

Method

The study was carried out with 36 pre-service history teachers (2 classes) from the second year of a three-year teacher education program, leading to a bachelor degree of history teacher in the first two grades of secondary education. The majority of the participants had received no prior higher education before starting with this program, and enrolled directly after graduating secondary education. Each students was randomly assigned to a dyad, in which he or she had to collaborate with a student from the other class.

During a four-hour intervention, student dyads collaborated on an inquiry activity within the WISE environment (Linn, Clark, & Slotta, 2003). Students had to study a collection of 8 historical sources describing the English peasants' revolt of 1381. Both fragments of original writings as well as excerpts from texts written by contemporary historians were included. Each student dyad was asked to review these sources in order to answer the following question: 'What was, according to you, the main cause of the revolt: grievances resulting from excessive taxation or complaints about serfdom?" After reviewing all the sources, students had to write an argumentative text in which they had to explain and defend their point of view.

Following a quasi-experimental design, students were divided over two conditions. In both conditions, students received roles to help them study the sources. One student had to act as a critic, while the other one was assigned the role of summarizer. Each time the students moved on to the next source, they had to change roles. In both conditions, the task of the critic was to rate the trustworthiness of the source and review the ratings given to previous sources. In the control condition, the summarizer was asked to examine what information was important. The summarizer in the experimental condition had to identify the source's point of view regarding the main cause of the revolts (choosing either grievances resulting from excessive taxation or complaints about serfdom), and use the information within the source to form arguments supporting or contradicting this point of view. After studying all sources, student dyads had to discuss the main cause of the rebellion. To stimulate discussion, each student was asked to defend on of the possible main causes, while their partner had to defend the other. It is expected that the collaboration script in the experimental condition will result in an increased attention for argumentation in students' interaction, as well as a higher quality of their argumentative text. It is also possible that actively using the sources' information to form arguments will promote a better understanding of the topic.

Therefore, participants' interaction during the task was be taped and subsequently transcribed, in order to conduct an analysis focusing on students' participation and the content of their interaction. Next to this, argumentative text each dyad composed makes it possible to examine the quality of each dyad's argumentation. Finally, a pre-posttest was conducted to measure students' learning gain. The posttest also included a compact measure regarding participants' experiences within the CSCL environment.

Results

Whether the experimental condition had an impact on students' interaction, the quality of their argument, or their learning gains will be determined through further analysis. As the study was recently conducted, preliminary results will be available by the time of the poster presentation.

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Understanding Participation and Persistence in Online Peer-to-Peer Learning

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Abstract: We present early work seeking to understand participation and persistence in online, peer-to-peer learning environments. We obtain log data from the Peer-to-Peer University (P2PU) and: (1) outline our methods to move from raw data to developing metrics that can help explore how to promote deeper participation and persistence rates in open courses, and (2) describe some preliminary findings about different metrics of participation and persistence in P2PU, culled from their log data.

Introduction

Open, online learning is a fast rising phenomenon in computer supported collaborative learning (CSCL). The growing library of open education resources (OER) combined with increased technology availability has created trends toward massively open online courses (MOOCs). Highly visible ventures such as Coursera, Udacity, and EdX have garnered much attention by attracting tens of thousands of learners (and sometimes hundreds of thousands) to their courses (Pappano, 2012). There are also other types of open online learning paradigms that are more learner-driven, bottom-up, and peer-to-peer. One such platform is the Peer-to-Peer University (P2PU), which is the focus of our research. In all of these different online learning platforms, the issue of learner participation and persistence is critical. Only a small number of learners even finish many of the high profile MOOC courses (Pappano, 2012), and peer-to-peer learning platforms are directly dependent on teacher and learner interactions to keep courses robust and active (Ahn, Weng, & Butler, 2013). A ripe area for future research is to understand metrics of participation and persistence in open, online learning. In this poster, we describe our early research with raw log data of the P2PU platform. We outline our methodologies in working with this data and preliminary findings about potential metrics of engagement that will inform future work.

Methodology

This study is a part of an ongoing partnership with P2PU where we are exploring how to create publicly sharable datasets and conduct analyses of this widely used open education platform. A major challenge of this type of research is to transform raw log data into a usable dataset that can be used to derive insight into open, online learning. We obtained data from P2PU that represented a log of all elements of the platform (e.g. courses, users, and learning activities etc.) in addition to all interactions that learners have had. This data captures a live snapshot of the system in July 2012. All measures represent the system at that point in time.

We used SQL to identify the tables, relationships, and data they contain. We also conducted direct observations of the P2PU.org website to identify how members go about: (a) joining learning communities, (b) interacting with peers, and (c) participate in learning groups. We then identified how these interactions with the P2PU.org community were represented in the underlying database structure. One critical issue in online platforms surrounds participation and persistence in open courses, so we concentrated our data investigation on understanding the characteristics of users and courses. We also developed a descriptive understanding of the P2PU ecosystem. Some of the characteristics we explored include: categories of courses in P2PU, the status of courses, the participation levels in courses, and the grouping of courses into schools.

Another goal of this initial analysis was to derive variables relevant to concepts of participation, engagement, and persistence in courses. Working from the data structures provided in the P2PU platform, we defined three types of measures that could be salient for future studies:

1. **Basic engagement**: The P2PU data allows us to track basic measures of course participation such as the number of participants, followers, and organizers associated with each course. We can also understand participation from the user's perspective, such as how many courses on average a user is a participant in.
2. **Active participation**: Beyond basic counts of participation, we also defined examples of active participation where users make explicit contributions to P2PU courses. These measures include statistics such as the number of comments shared in courses or learning groups.
3. **Metrics of Persistence**: We were also interested in measures that reflect whether learners complete learning tasks and progress through courses. We derived two types of metrics from the P2PU log data.
    a. Task Completion Rate – Many P2PU courses have tasks that learners are asked to complete. We were able to derive an average completion rate for each P2PU course, which was found by calculating how many tasks on average, participants completed, divided by the total number of tasks designed in a given course. In this way, we may be able to compare the completion rates of different types of courses in P2PU in future work.

b. Badges Earned Rate – Learners can also earn digital badges in the P2PU platform. Badges serve many social and educational functions (Antin & Churchill, 2011; P2PU, 2012). We are able to track the total number of badges earned by each learner across courses, in addition to the badges that could be potentially earned in a given course. Using these metrics we can calculate a metric of badge earning rate in each course, dividing the average number of badges a person earns by the total number they could potentially earn in a given course.

Preliminary Findings

Descriptive summaries of the measures are included in Table 1. We found much variation between P2PU courses in terms of the level of participation as well as in the range of activity.

Table 1: Descriptive summaries of participation and engagement measures across P2PU course

	Mean	Std.Dev	Median	Min	Max
Basic Engagement					
Organizers	1.5	3.712762	1	1	98
Participants	32.0	88.32164	8	1	853
Followers	5.7	31.46898	1	1	594
Participation	3.9	3.8	2.7	1	24
Active Participation					
Comments/Posts	12.5	44.2	2	1	388
User Achievement					
Task Completion Rate	51%	20%	50%	2%	90%
Badges Earned Rate	62%	27%	50%	18%	100%

In addition to targeting the specific engagement measures, this research also allows us to create a descriptive summary of the ecosystem of P2PU. The components of that ecosystem are the schools, courses, learners, tasks, and badges. We have identified 6 schools in P2PU. There are 1333 total courses. Of these 25% are active. Courses belong to course types: Study Groups (57%), Challenges (17%) and Courses (26%). A total of 34,777 learners have created accounts with P2PU, however only 4,576 are active participants, learners who have returned to the site multiple times, registered for multiple courses, or created content posts. Finally, as learners progress through courses, they complete tasks and earn badges to mark their progress. Badges are used as a tool of motivation to keep the learners engaged in the courses. Task completion and badge earning measures are described in Table 1.

Discussion and Conclusion

This poster describes the very early work we are undertaking on open, peer-to-peer learning in P2PU. We have begun the process of converting log data into usable datasets to glean deeper insight into the P2PU platform, and how learners participate in and persist through open online courses. Initial descriptive analyses are presented here, but these metrics of participation and engagement will serve as the foundation for future research. For example, in future work we plan to examine whether the characteristics of courses and learners in P2PU relate to metrics of persistence such as completion rates and badge earning. These future studies promise to shed light on factors that might help improve learner engagement in open, online learning, which is a topic that is gaining tremendous traction and visibility in the coming years.

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When Ideas Learn How to Fly: Children at the Intersection of Formal and Informal Learning Settings

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Abstract: With after-school initiatives on the rise and an increasingly standardized educational system, children's learning is influenced from two rather different ends. The children's learning processes are torn between the necessity to 'function on demand' and perform well in school lessons, tests and educational surveys, and the need for playful exploration. This study of computer-related project work in an intercultural after-school initiative explores the interplay and interdependence of child learning in formal and informal contexts. Main findings indicate that a close link of both contexts can 1) support the learning effect, and 2) strengthen the after-school initiative's standing, 3) increase potential learner's motivation to participate in it, and 4) locally support cross-cultural understanding and respect.

Introduction

How can learning be promoted in an everyday life that has become increasingly socially and culturally diverse? The answer to this question lays the foundation on which learning opportunities in intercultural settings are successfully implemented. They can help learners of various cultural and social backgrounds see the relevance of their learning in their everyday lives, newly value the importance of learning as an entrance key to multiple parts of life, and contribute to cross-cultural respect. Educators have approached these answers from different ends. The understanding of learning as a lifelong activity has spread, and after-school initiatives have become increasingly popular. Also, the formal educational system became much more focused on excellence and performance. This study of computer-related project work in an intercultural after-school initiative explores the interplay of learning in formal and informal contexts. We analyze how the link of formal and informal learning can support the effect as well as strengthen the informal learning setting's standing, increase motivation to engage in it, and thus contribute to cross-cultural understanding and respect on the local neighborhood level.

Related Work

The development of formal and informal learning has long been on the agenda of researchers in education and the learning sciences. Hsi et. al. describe the *'core identifiable features'* (Hsi et.al. 2004, p. 12) of informal learning to be the self-directedness, temporal absence of administration; fluid arrangements with regard to participation, time, and space; and great diversity of learners with regard to age, race, and ethnicities. Clegg et. al. (2006) explore the transferability of learning experiences, concentrating on activities and artifacts that worked well at motivating learning. Several other studies share the focus on motivation (e.g. Barkhuus & Lecusay 2011). Regarding formal learning, research is concerned with ICT use in schools, with children's ICT related learning and play strategies, and with teachers' use of ICT in class (e.g. MacFarlane et. al. 2005).

Computer clubs 'come_IN' are situated at the intersection of formal and informal learning. This setting provides the chance to study not only the development of a project-related learning process, but also see how formal and informal learning intersects, overlaps and can assemble in a fruitful combination contributing to integration in an increasingly diverse society. The 'come_IN' computer clubs build upon the US initiative of computer clubhouses. Relying on principles of situated, collaborative learning and constructionist thinking, the latter address inner city youth with educationally and socially deprived backgrounds, aiming to open up chances. Their success is well documented (e.g. Kafai et.al. 2009). Building on this, 'come_IN' clubs foster community dynamics and strengthen social ties on the family, school and neighborhood level. Also, the project work strengthens individual skills. Schools in intercultural German neighborhoods as the clubs' location are the starting point for interactions drawing on shared experiences. Project work is conjointly decided upon and often relates to local issues (e.g. Schubert et.al. 2011). The first 'come_IN' club was founded in Bonn Nordstadt in 2004. In Siegen, the transferability of the concept was tested in 2006. Four clubs were founded in 2009: two in a school complex in Bonn Tannenbusch, one in a primary school in Dortmund (being in the focus of the study presented here), one in a youth center in Kreuztal. In 2010 another club followed in a school in Kreuztal.

Method and Data

Field notes have been taken by the researchers acting as tutors during club sessions, following a participatory action research approach (Kemmis & McTaggert, 1988). The club in Dortmund is at the center of this study. It sees 4-7 adults and 7-10 children every week. The project developed over the course of seven months. Online trackable log files have also been analyzed. Coding (Strauss & Corbin 2004) was guided by our focus on the interplay of formal and informal learning and its technological support in an intercultural after-school setting.

Intercultural Project Work in Practice: Results

The idea of constructing items that would then be sent as so called trackables on a geocaching *'world tour'* appealed to the participants. It was decided to build dragonfly trackables, because the school mascot was a dragonfly. For the finalizing of their design, participants would write texts about themselves, the computer club, their dragonfly, and its destination. This text was also put online on the geocaching website. Each trackable was given a geocaching coin with a unique number used to track the item. Several participants linked the trackable design to their migration backgrounds, e.g. deciding that the dragonfly should see Albania. Others related travel descriptions to local things, or to personal issues – like one boy, who was facing a lot of conflict at home: he made his dragonfly fly to places '*where there are happy people'*. A large nearby cache was identified by means of GPS-devices, so all club teams could 'set their dragonflies free'. The geocaching website was used to follow the route of the trackables. A map was put on a wall in the computer room, on which the location of each trackable was updated weekly. As the dragonflies crossed borders the club participants turned to online maps to keep track of the travels. Children would also watch their trackables online from home, or demand access to the classroom's PC to view the progress. Children were calculating distances and excitedly handling large numbers they had just familiarized themselves with in their math classes. Enthusiasm with the 'dragonfly world travels' carried the club that far that the project was never finished but turned into an underlying long-term endeavor.

Intercultural Project Work in Practice: Analysis

Our analysis saw the project work unfold in three subsequent phases, each combining formal and informal learning processes. There was the first phase of the project, where club participants developed the idea, familiarized themselves with the concept of geocaching, planned and implemented the actions necessary for the project to start. We saw how formal learning from regular school lessons had laid a ground that the project related informal learning could build upon. Children made use of the language and writing skills they had acquired in class, and used it first to negotiate a travel destination, and then to write the accompanying texts for their trackables. Awareness for individual characteristics and cultural background unfolded on the informal level of learning, and children explored how these could find an expression. The excursion part provided participants with the opportunity to familiarize themselves with their neighborhood. By following their trackables online, this awareness was deepened. The competitive aspect turned out to be a great motivator: not only did children ask *Where is my dragonfly?*, they also compared *Where is my dragonfly in relation to other dragonflies?*, playfully engaging with math. Finally, children informally learned: 1) cool things can be achieved by working together, 2) some things take time to develop, and 3) supposedly boring lesson contents can serve fun purposes.

Conclusion

In our case study of the geocaching project we saw several formal and informal learning steps unfold. Most prominently among them was the support of language acquisition and eloquence promoted through the writing and reading involved. We saw the project trigger self-organization among participants. Also, children and adults learned more about themselves, their neighborhood, about their position in the city and beyond. Finally, we saw self-confidence and openness with regard to other people, and patience with regard to backlashes be involved.

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SiMSAM: An Integrated Toolkit to Bridge Student, Scientific, and Mathematical Ideas Using Computational Media

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Abstract: We are developing SiMSAM (**Si**mulation, **M**easurement, and **S**top **A**ction **M**otion): an integrated toolkit for middle school science. SiMSAM enables students to construct animations, crop images from those animations to use as programmable simulation objects, measure patterns in simulations, and share creations. We present (1) analyses of video data from a pilot design studio focusing on patterns in students' representational choices, scientific engagement, and attention to causal mechanism; and (2) prototypes of SiMSAM for feedback.

Motivation and Objectives

There are calls for K-8 science instruction to build on students' existing ideas about the world; involve students in proposing and refining models and explanations; and engage students with the tools and discourse of STEM professionals (NRC, 2012). Increasingly, computation and simulation are the tools scientists use to explore and communicate complex ideas and data (Chandrasekharan et al., 2012; NRC, 2010).

We are developing SiMSAM, a web-based toolkit to engage middle-school students in a technology-mediated modeling continuum: including theorizing, model construction, testing, sharing, and iterative refinement. SiMSAM enables students to (1) build stop motion animations of kinetic molecular phenomena using paper drawings or physical props, (2) crop images from those animations and program them using domain-specific visual manipulations to create a simulation of the modeled phenomenon, and (3) analyze the simulation using measurement and graphing tools. It will also (4) support networked sharing for students to critique, refine, and build upon their classmates' work.

SiMSAM is informed by Constructionist (Papert, 1980) and representationally mediated (Kaput, 1998; Vygotsky, 1978) theories of learning, and is based on the premise that students need a supportive continuum from discussing ideas to mobilizing those ideas for constructing computational models. It builds on prior simulation and animation tools that have been shown to support student learning and engagement around molecular theory (Chang, Quintana, & Krajcik, 2010; Tinker & Xie, 2008; Wilensky, 2003). We merge these approaches so that at all levels, *students' ideas are the substance of construction*: they create or select their *own* objects (or those of their classmates), define their *own* rules to govern object interactions, and define their *own* measures to explore simulation outcomes.

Research Questions

We are using SiMSAM prototypes and existing tools as a design-based research environment (Cobb et al., 2003) to explore how students express and translate ideas across different multi-modal discourses. Data yielded will speak to two open questions:

RQ1. To what extent can SiMSAM support a "continuum" in which students express and maintain ownership over their ideas across different representational media?

RQ2. Which aspects of students' understanding of kinetic molecular theory persist, shift, appear or disappear as students construct models across different representational media?

Data and Preliminary Results

In Fall 2012 we conducted a "design studio" (Druin, 2002) with five sixth-grade girls using existing animation and simulation tools (SAM Animation and StageCast Creator). We held four sessions where participants theorized and tested one another's ideas about how an orange is smelled by a person standing at the other end of a room (Schwarz et al., 2009).

In Day 1 we discussed smell diffusion in a group, and asked students to draw models and create SAM animations of smell diffusion. In Day 2, we revisited the girls' animations, and introduced them to StageCast Creator. In Day 3, the girls continued to work on their simulations, and in Day 4 revised their simulations and began to measure the resulting patterns generated by counting the number of smell particles (what they called "Oogtum") reaching humans at different places in the simulated world.

We analyzed video from all four workshop days in five minute segments, using established frameworks to code each segment for evidence of modeling practices, scientific inquiry practices, facilitator moves, reasoning about mechanism, and student ideas related to smell and particulate models of matter. We present patterns in the ideas and practices that emerged, persisted, or waned as students expressed or tested their models in different media.

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Supporting science practices outdoors with mobile devices: Findings from the Tree Investigators augmented reality project

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Abstract: This research examines how *Tree Investigators* supported families' science learning with mobile devices. Researchers coded videorecords of families at an Arboretum to understand how augmented reality elements influenced science talk related to observation and explanations about tree biodiversity. Findings suggested that augmented images that provided contrastive cases allowed for families to engage in observations and explanations as demonstrated by high levels of perceptual talk (such as describing and identifying).

Theoretical framework

Our research and design intention is to support families to be competent scientific observers and explainers of natural phenomena through employing mobile technologies. Mobile technologies have been used to support engagement in outdoor settings (e.g., Liu et al., 2009; Rogers, et al, 2004; Tan et al., 2007), as well as to augment real-world locations with virtual data and gaming scenarios (e.g., Klopfer, 2008; Squire & Jan, 2007). Researchers have reported design elements for mobile devices that encourage data collection (Squire & Klopfer, 2007) and engagement in discourse (Rogers, et al, 2004; Tan et al., 2011) that support science learning. Building on this prior work with mobile technologies, our research framework brings together theory about technological supports (Quintana, Reiser, et al., 2004) with theory about using talk to encourage observation and explanation practices (Bell, et al., 2009; Berland & Reiser, 2009; Eberbach & Crowley, 2009). We designed Tree Investigators as a mobile website (see Figure 1) that uses augmented reality (images and text layered onto the physical space) to support families to develop observations and explanations related to tree biodiversity. Our research investigates the following question: How do youth and families talk together about trees and biodiversity while using the Tree Investigators augmented reality program on mobile computers?

Methodology

We conducted a video-based collective case study at an Arboretum (5 hours of video) to understand how mobile devices using augmented reality could support scientific talk. The participants were 25 people from 11 families. Families were videorecorded during a 1-hour guided tour using augmented photographic and textual elements on tablets, smart phones and mp3-players. Given our interest to support science learning in informal spaces, the study's analytical framework considers spoken conversation elaboration (Leinhardt & Crowley, 1998) as a product and process of learning. We used a theoretical-driven approach to code transcripts for evidence of observation and explanation during the Tree Investigators experience. The coding scheme was derived from Allen (2002) as shown in Table 1; in addition, we included a sixth code: reading aloud.

Table 1: Analytical framework applied to family talk while using Tree Investigators.

Code	Description	Exemplar from our data set
Perceptual talk	Identification, naming, describing.	• . . . all the branches are all on the top.
Conceptual talk	Inference, interpretation, prediction.	• This one drops its leaves.
Connecting talk	Life, knowledge, inter-species connections	• They do have those – we were at the Pittsburgh zoo…
Affect talk	Expressions of feeling	• That one's interesting.
Device use	Clarification for device functions	• . . . you had to hit something to take a picture.

Findings

Based on a detailed line-by-line analysis of the families' talk using the Allen (2002) coding scheme and thematic analysis procedures, we found individuals used the Tree Investigator augmented reality images and text to support their observations and understandings of trees, as shown in right-hand column of Table 1 and in Figure 2. Families used the mobile devices in the outdoor setting to coordinate observations with scientific knowledge to support the development of explanations. Images and prompts (see Figure 1) that were part of an AR mobile website were used to support family observational practice and to develop explanations about the differences in trees and their characteristics related to biodiversity. The Tree Investigators' program supported the families so that they: (a) noticed relevant aspects of the trees in the seasonally dynamic environment; (b) articulated understandings of scientifically-relevant aspects of the trees; and (c) understood differences between evergreen and deciduous trees. Our findings suggest the importance of augmented photographic elements (such as flowers, nuts, and leaves that were not seasonally available) as contrastive cases to the onsite specimens to support deep observational and explanation practices.

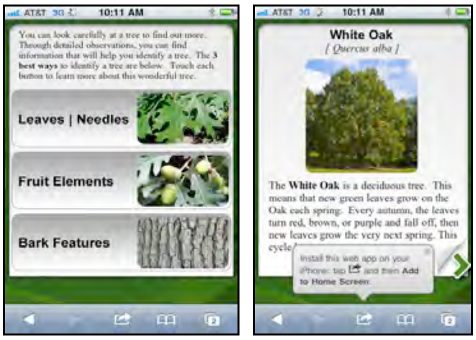

Figure 1. The Tree Investigators interface.

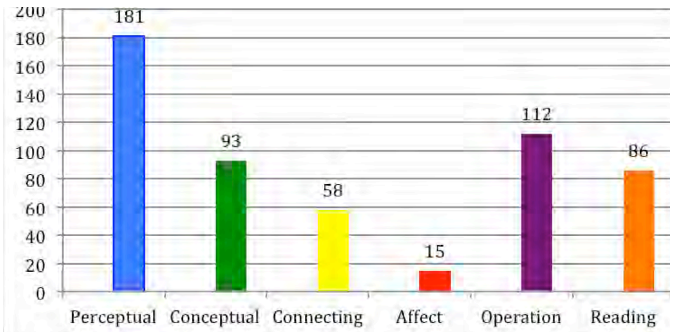

Figure 2. Talk across all the family members.

Discussion and Implications

The significance of this line of work lies in its contribution to the growing literature on technologically-enhanced lifelong informal learning, as shown through the Tree Investigators program supporting scientific talk through AR textual information and visualizations on the mobile website. Given our findings on the way that contrastive images supported elaborated family talk, this study supports efforts to utilize augmented reality approaches on mobile devices to support informal science education. This study suggests the need for additional research on how mobile technologies can be used by families and other learners in out-of-school venues.

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Volume 2

Keynotes

Why do apes cooperate?

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Cooperation is ubiquitous in the animal kingdom and yet, humans have turned cooperation into one of their defining features. Our level of cooperation has become such that members of our species can cooperate with large numbers of genetically unrelated partners for extended periods of time, in some cases spanning generations. How did this come about over evolutionary time? In this talk, I will turn to our closest living relatives, the great apes, in an attempt to throw some light into this question. I will explore the prosocial behavior of the great apes defined as one individual doing something resulting in the benefit of another. In particular, I will present data on helping and collaboration in chimpanzees, bonobos, and orangutans and compare it with data on children presented with comparable tasks. I will use these comparative data to uncover the socio-ecological and motivational factors that determine the emergence of cooperation in humans and nonhuman apes.

Connecting Kids: The Future of Video

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Understanding how kids connect with video may hold the key to delivering the long-awaited promise of video communication. Children's play is rich, creative and imaginative and research shows that children's play easily transcends distance through the use of video. And remarkably, children are extremely comfortable interacting over video. This talk highlights several recent projects that demonstrate children's rich, social interactions using video to connect with friends and family, regardless of whether they live in the same neighbourhood, or on the other side of the world. As these technologies become embedded into the fabric of daily life, video will transform children's social interactions in both learning and play, enabling them to share rich experiences in ways not possible with current technologies.

Connection Machines: The Role of Rapport in Computer Supported Collaborative Learning

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In thinking about the ways in which computers can support learning we often concentrate on the task or cognitive aspects of the collaboration between human and machine. However, the social nature of some of the best kinds of human-human learning interactions does not need to be left behind in human-computer collaborative learning, and understanding the social nature of human-human peer collaborative learning can help us to design computational systems that are most effective in real world contexts. To that end, in this talk I report on a series of studies that look at the building of rapport between humans over time, and between humans and computational systems. I look at the effects of this rapport building on peer learning among young children, junior highschool students, and adults, when the learning partners are actual human peers and computer peers. From the results of these studies I draw conclusions about the need for studies of actual human-human interaction to inform the design of collaborative learning technologies and, more generally, the need for models of the interaction between humans and computers to draw on not just technical but also social and cultural phenomena.

Volume 2

Demonstration Papers

InterLACE: Interactive Learning And Collaboration Environment

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Abstract: InterLACE is a new web-based platform developed to support collaborative learning in the classroom. It is designed to quickly and easily capture student ideas and representations using any computer, tablet, or smartphone. With a persistent, shared workspace, students' ideas can be visualized and manipulated to support group sense-making class-wide.

Purpose

The InterLACE Project aims to develop and test an innovative web-based computer supported collaborative learning (CSCL) environment to support co-located collaboration in high school physics classrooms. Students benefit from sharing their ideas as well as viewing, organizing, and refining one another's ideas as they emerge. InterLACE has been designed to lower the implementation barriers to collaborative learning (Hynes et al, 2012) for teachers by making it easier to monitor student discourse and adjust lessons on the fly when the situation demands. The first InterLACE tool, developed and tested in five Boston and New Hampshire high school classrooms, provides a shared, interactive work space to facilitate collaborative learning. Students can post, visualize, build on, reorganize, comment on, reflect on and improve their own and/or fellow classmates' ideas. It enables students to use the virtual artifacts they create to build knowledge together, argue for their point of view, make connections, and expand on one another's ideas, resulting in deepening and broadening the collaborative dialogue and knowledge building activities.

Contributions

Building on lessons from learning sciences, CSCL views learning supported by technology as the "shared effort of students to build shared meaning interactively" (Stahl et al, 2006) rather than just absorb facts from the teacher. This involves: active engagement, a focus on knowledge construction, idea improvement, feedback and adaptive instruction. CSCL technologies support these collaboration activities by providing a "joint problem space" (Teasley & Roschelle, 1993), or shared dynamic interactional space where class-wide knowledge-building can take place and students can observe each others thinking.

To that end, the technical team has created a flexible web-based tool that provides a persistent whiteboard-like work space (see Figure 1) that makes student ideas available for class-wide visualization, discussion, joint organization, manipulation, and improvement, all of which can lead to the construction of a shared understanding of the concepts being studied.

Learners represent ideas in different ways, so any technology must be flexible enough to support a variety of representation types. Currently, students can develop their ideas using text, images, screenshots, and sketched drawings (see Figure 2), with a plan to add videos. These representations are aggregated within the tool and visible to the entire class on students' computers, smart phones, or tablets, as well as on the SMART Board or screen at the front of the room. Teachers are also able to embed rich media and simulations into their lesson plans.

Both students and teachers can dynamically rearrange these Post-it note type objects to identify patterns and connections across group responses (see Figure 3). Additionally, members of the class can use InterLACE's comment feature to build on and refine others' ideas, reflect on work, show support, and critique or defend ideas in real time. Teachers can contribute to the discussion, provide quick feedback, and monitor students' understanding. Individual student contributions can be highlighted for viewing, along with side by side comparisons from multiple students, to engage the entire class in a process of scientific argumentation and collaborative sense-making (Danahy et al, 2012). Instead of the teacher eliciting and evaluating responses and then synthesizing them, InterLACE encourages all students to contribute to the conversation and engage in the evaluation of how ideas relate to one another.

InterLACE supports and enhances students ability to participate in interactive, class-wide, multimodal discussions. Students' ideas become the focus of the classroom work. Information contributed by individuals with different perspectives can help the group pull together pieces of a problem other members hadn't considered to create better understanding for everyone. It enables the capacity for on the spot feedback based on students' ideas. Finally, using InterLACE, students can read and interact with the ideas of classmates, thus making their own thinking visible. All of these skills are critical to being an educated person in the 21st century.

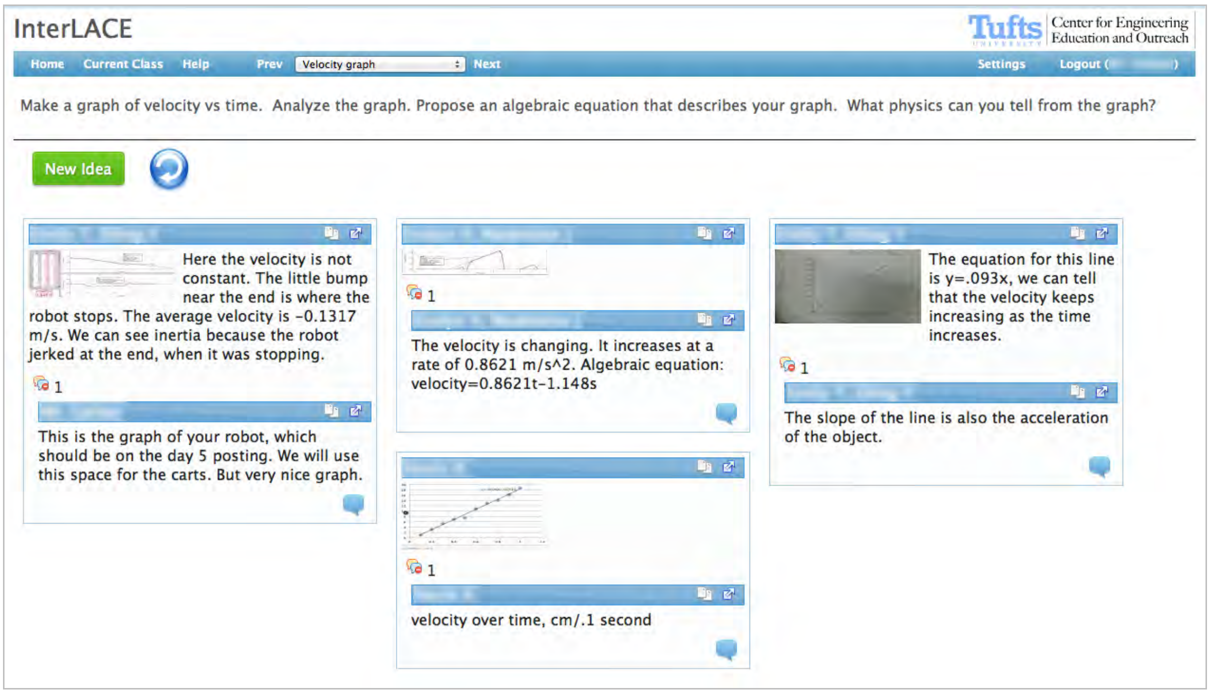

Figure 1 – Whiteboard Work Space

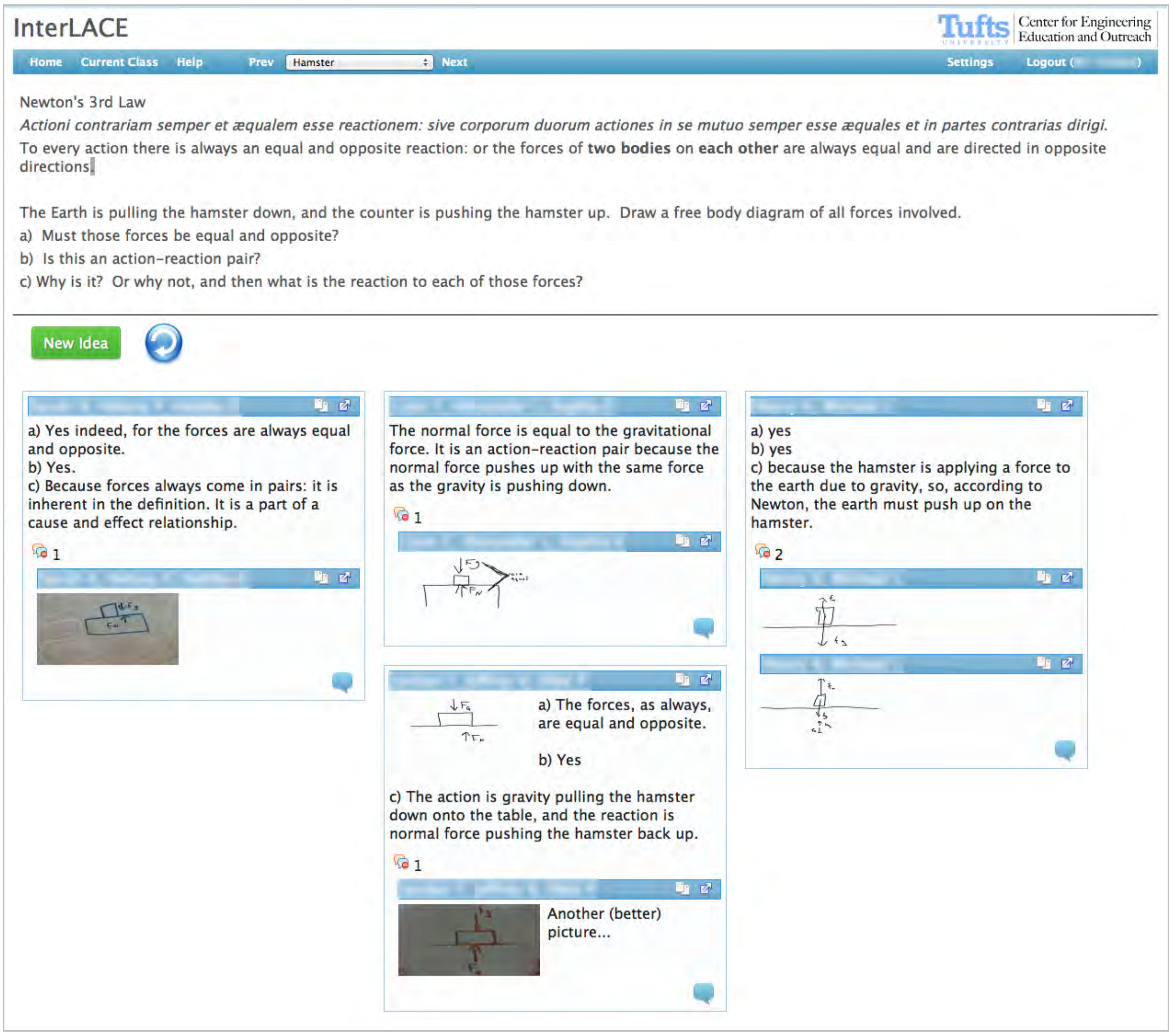

Figure 2 - Flexible Idea Representation

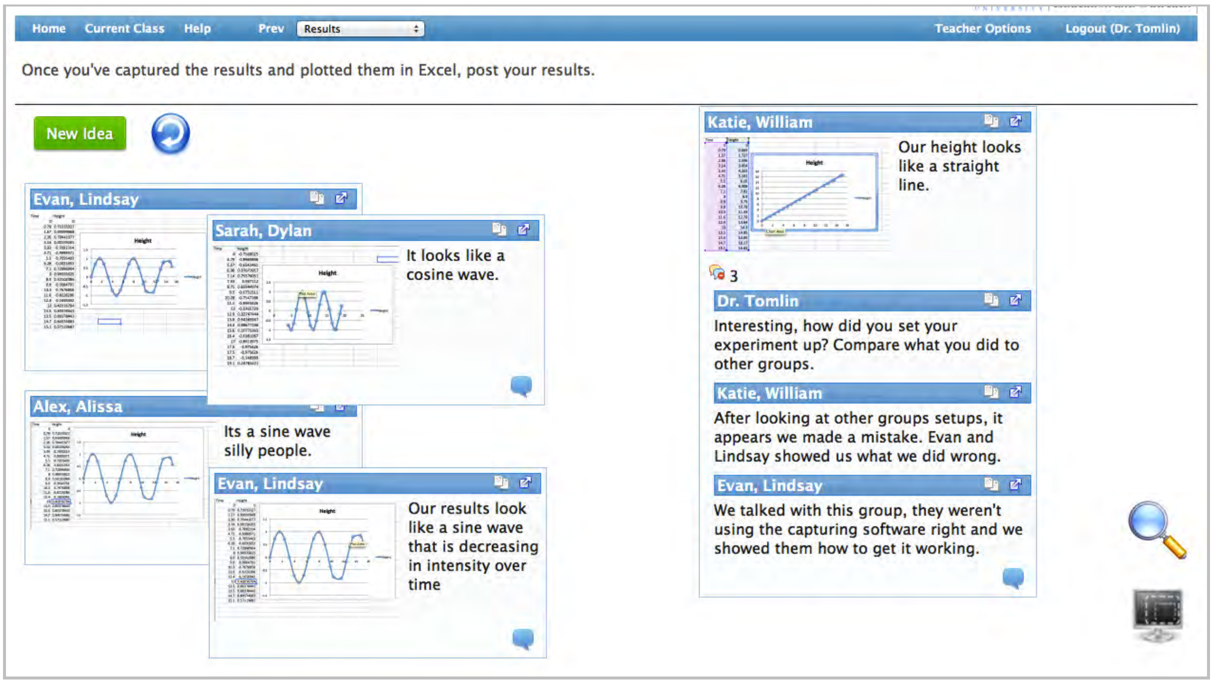

Figure 3 - Arrangement For Group Sense-making

Demonstration Experience

There will be two main goals of the demonstration. First, to demonstrate the capabilities of InterLACE and give participants a sense of how it can be, and has been, used in the classroom. Second, to solicit feedback from the audience about the direction the research should take next.

Audience members will be given the opportunity to directly interact with each other via InterLACE. A class session will be created specifically for the conference presentation. Participants will be given the URL and password, and after logging in they can specify a display name and enter the class. Then we will highlight several of the novel contributions of InterLACE:

- Idea representation must be flexible - Learners represent ideas in different ways (Rose and Gravel, 2010), requiring technology flexible enough to allow them to choose the representation that best captures their thought process. The demonstration will ask users to provide several different forms of rich media and text.
- Multiple platform integration – Built entirely in HTML5, InterLACE can be used on nearly every computer, tablet, phone, operation system, and browser. The research team will provide several different tablets that participants can use, in addition to their own computers.
- The power of persistence - As users answers are quickly displayed on the main projector, they must take ownership of their idea and be able to explain their thought process. Persistence plays many rolls in collaboration, from reducing cognitive load to improving parallel communication (Gergle et al, 2004) (Cherubini & Dillenbourg, 2007). Our observations show this persistence to be powerful in the evolution of the groups' shared sense-making.
- Simplicity and Speed – Through observation and discussion with teachers, we determined that time overhead involved in implementing technology-assisted collaboration into the classroom is a major barrier to implementation. Installing software or plug-ins takes significant effort. Students forget passwords or are confused by overly complex interfaces. InterLACE was designed to quickly capture ideas via interfaces that are intuitive and simple to navigate.

Participants will be prompted to respond to several questions, which will be relevant to the topic at hand. They will be able to use their own devices (provided there is a good wi-fi connection), as well as devices the research team will provide.

For this scenario, the questions would be simple and fun, with the first one being an opportunity to take a picture of themselves and give a short introduction. Participants can use the camera on their computer or tablet to take a picture and post their name/affiliation. Subsequent questions will attempt to both demonstrate the systems capabilities and potential use cases. Once participants have a sense of the goals of the project and the affordances of the software, they will be asked to provide feedback in areas that we are interested in perusing.

- Scaffolding – InterLACE contains less built-in scaffolds than well-known CSCL systems like Knowledge Forum, and instead relies on the teacher to provide much of the scaffolding. How can scaffolds be introduced in less rigid ways, specifically ones that build on users' existing affordances learned from social media?
- Assessment – Tools are currently in development to assist teachers in evaluating student contributions in InterLACE, but what else can be done from both a technology and pedagogical perspective to help teachers assess collaborative activities?
- Evaluation – How would participants set up controlled experiments to evaluate InterLACE as a CSCL system? Users are often co-located when using InterLACE, therefore communication takes place both online and off. How would participants combine log file data with information from coded video files? What particular aspects should we be looking for, such as inter-group communication? What does the role of the actual student content contributed to InterLACE play in evaluation?

This demonstration design will allow both participants and presenters to learn from one another and each take something of value from the session.

Supporting Materials

The research team has produced a video demonstration.

Video: http://youtu.be/CaANnbp9ZD4

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The Metafora Tool: Supporting Learning to Learn Together

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Abstract: Collaboration in complex learning scenarios does not succeed automatically without structuring the learning process. The Metafora project (http://www.metfora-project.org) is designing a pedagogy and a platform of web-based software to support learning to learn together (L2L2) in the context of math and science. The platform serves both as a toolbox of various learning tools and as a communication architecture to support cross-tool interoperability. The central tool in the Metafora system is a web-based application offering a visual language for planning, enacting and reflecting on learning activities. In the demonstration we will present our pedagogical approach for supporting L2L2 activities and the platform developed on the basis of this understanding. In particular we will demonstrate how the platform can be integrated in successive activities.

Learning to Learn Together and the Metafora tool

Most knowledge creation is conducted by teams and not by individuals. In addition, learning mediated by the Internet is often focused on learning together with others. It is therefore important that we teach and support the complex competence of learning to learn together (L2L2). While there has been some research on learning how to learn (L2L, e.g., Claxton, 2004; Fredriksson & Hoskins, 2007; Higgins et al., 2006), there has been little research on L2L2. Learning how to learn together implies that all the group members are able to coordinate, regulate and plan the learning task by balancing issues of individual ability, motivation and expectations through constant dialogue. The process of L2L2 can be described and studied by analyzing the groups' collaborative learning activities and behaviors as a set of sub-skills: distributed leadership, mutual engagement for fulfilling collaborative tasks, a dialogue where students can discuss their ideas and create new ones, and peer group assessment, where members give and accept feedback from each other, routinely reflecting on their work.

The Metafora project (http://www.metfora-project.org), funded by the EC, is designing a pedagogy and a platform of web-based software to support L2L2 in the context of math and science. A key technical and pedagogical innovation of the project is to support L2L2 within a group of learners. We present our platform (see Fig. 1), which serves both as a toolbox of various learning tools and as communication architecture to support cross-tool interoperability. The toolbox facet of the system provides a graphical container framework in which the diverse learning tools can be launched and used. Basic functionalities that is globally available are user management (login/logout and group membership for both local groups of students sitting at one computer as well as remote, collaborative groups), a chat system to discuss and organize work between group members, and a help request function that is present across the entire platform. Below we describe in some more detail certain components and features of the Metafora system.

The planning/reflection tool

The planning/reflection tool offers a visual language that enables students to create and map representations of their work for planning, enacting and reflecting on Metafora learning activities (see Fig. 1). The main feature of this tool is the use of cards and connectors to present a plan for future work or to create a diagram of work completed for reflection. The cards contain visual symbols and titles, as well as space to insert free text (see Fig. 1) The symbols and the titles represent different stages and processes related to inquiry learning (e.g., experimentation, building models, making hypotheses), attitudes taken towards the group work (e.g., being critical, being open) and cards that allow access to different resources within the Metafora tool box (e.g.

LASAD, microworlds, etc). The connectors represent relational heuristics ("is next", "needed for" and "related to") to explicate how the various cards are related in the given plan.

Although it is built as a stand-alone web application, it is most effective as an embedded tool within the Metafora platform, acting as an entry gate and pivot to the other tools. Students can create and modify plans for facing various challenges in math or science. The students can also invoke other tools, including microworlds and discussion tools, and utilize them through specialized resource cards that are part of the visual language. With the planning tool, students describe how they will tackle their current challenge using the visual language as a guide and then move together through the various planned stages, enacting activities and noting when activities are started and completed. Thus, the plan is also a visual representation of the groups' achievements and current status.

Microworlds integrated in the Metafora system

Metafora provides five microworlds that are fully integrated in the Metafora platform. These microworlds serve as an arena for inquiry and constructionist work. (1) eXpresser: a microworld designed to support students in generalizing rules based on the structure of figural patterns of square tiles. In eXpresser, students construct animated models comprising patterns of repeated building blocks of tiles. (2) The "3d Math" Authoring Tool: a 3d programmable environment inside which users may graphically represent and manipulate 3d objects that they either find ready-made in an embedded library or construct themselves when using Logo procedures and commands. (3) The "Physt 3d" Authoring Tool: a 3d programmable environment that allows teachers (i.e. "the Pedagogical Designers") to create 3d game-like microworlds (e.g. the 3D Juggler microworld), for simulating phenomena defined by Newtonian Laws. (4) Sus-City: a game template for non-technical users (teachers and students) to construct and play their own "Sustainable City" games. The game design is based upon two types of user intervention: a) adding content on the template, i.e., the city terrain, city sites and site properties and b) defining the initial set of values for the player and the threshold values which indicate violation of the system and end of the game. (5) PiKi: a microworld that addresses kinematics through a serious game with a pirate-based theme. Other microworlds like Geogebra can be integrated with the Metafora system in a less integrated way, but still allow productive collaborative inquiry based activities.

Discussion tools and referable objects

Metafora provides discussion tools to allow general communication and collaboration, but also aims specifically to support the L2L2 process by allowing discussion and argumentation spaces to integrate artifacts created in other tools. Two discussion tools serve different purposes. First, the chat tool offers a quick and ever-present space for students to gain each other's attention and share informal thoughts in situ. Second, LASAD (Loll et al., 2012) offers a structured approach to discussion through argumentation graphs (see Fig. 2), which have been shown to improve discussion and argumentation skills (Scheuer et al., 2010). Both the chat functionality and the LASAD system are customized to display and offer links to *referable objects* that reside within other tools. These referable objects are artifacts shared from other tools that can be viewed (text or thumbnail images) as components of the discussion, but can also be accessed in the context of the original tool through return links (see an example in Fig. 2). This need emerged from early experimentation with the system and was supported by previous related research (e.g. Stahl, 2006).

Figure 1. Screenshot of the Metafora platform with several learning tools opened (see tabs on the upper border). The planning tool is shown in the center (started activities are marked in yellow, finished activities in green; the arrows are connectors symbolizing the relations between the visual cards).

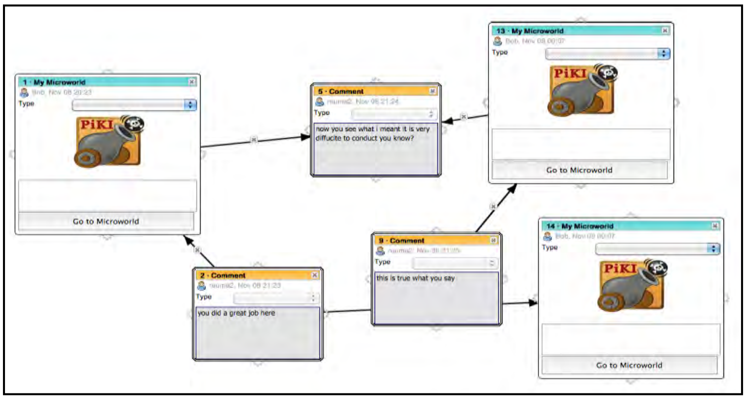

Figure 2. A discussion map in LASAD with embedded referable objects from a microworld (PiKi)

By using referable objects, students can include planning cards and/or microworld objects in their discussion without the need of anaphoric or deictic language. These direct references allow continuous dialog that is explicitly linked with and contextualized by the students' work in other tools. In this way, referable objects allow students to more easily and naturally engage in L2L2 activities such as offering help to one another, and reflecting on ideas and hypotheses in an ongoing process of negotiation of new meaning for created artifacts.

Analysis and visualization

Each software tool stands as an independent learning tool and can offer its own automated analysis of student work through individual analysis components. Analysis ranges from low-level activity indicators (such as indicating the creation or modification of artifacts) to high-level analyses (such as identification of whether a student is struggling). The intelligent components of the tools that create these various analyses report them to a centralized analysis communication channel for the entire Metafora platform. A cross-tool analysis agent then monitors this channel and offers higher-level analyses of student work. Defining and creating these high-level analyses is an ongoing effort based on prototypes and Wizard-of-Oz experimentation. The theory behind this work and first implementation steps is described in more detail in (Dragon et al., 2011). This analysis information is used to offer both direct feedback to students (through a notification system) and useful summary information to both students and teachers (through visualization tools that filter and aggregate information). The specifics of the information that should be displayed, to whom and when, are currently under investigation.

L2L2 in Metafora and its significance for CSCL research and practice

The Metafora system is conceptualized and implemented as a full-fledged web-based application, with the platform and diverse learning tools running in a web browser. Thus, it is easily accessible and built to integrate third-party web tools to support complex L2L2 scenarios. Our current primary set of learning tools described in the earlier section is specifically designed with the L2L2 principles in mind and with a high degree of semantic interoperability, i.e., seamless transition between the different tools via referable objects and the potential for cross-tool analyses. The growing maturity of the system has already been demonstrated with extensive experimentation of the pedagogical scenarios in classrooms (see, e.g, Metafora public deliverable[1]). This practical application and the empowerment of teachers will continue. In the future, the system will also be used as a research platform for a variety of complex learning scenarios. The ongoing data analysis of experimental data will provide insights into the nature of L2L2 and how the analytic system of Metafora can be enhanced to support students. The automated analysis of Metafora extends the automated work of collaborative learning scenarios that has been developed in earlier work (see, e.g., the work on ARGUNAUT (McLaren, Scheuer, & Mikšátko, 2010) and that of Rosé and colleagues (Rosé et al, 2008)). Metafora pushes the envelope on prior automated analyses by providing analyses across a variety of learning tools (Dragon et al., in press).

We argue that Metafora's unique contribution to the CSCL agenda is its ability to afford and explicitly represent the group work as a collaborative artifact (in the planning/reflection tool) and as such expose it as a subject of group discussion. Planning and reflecting activities make students focus on the meta-level task of understanding how their group succeeds or struggles in planning and enacting their work. The planning tool - used as a gate to all the tools integrated in the Metafora toolbox - plays a crucial role in this process and as such is the most significant tool developed in the project. This tool allows students to elevate their thoughts and discussion beyond the content of their task, and motivates reflection on how they work together and how, as a group, they can succeed in their learning objectives. We recognize this higher-level student effort as Learning To Learn Together (L2L2), a collaborative learning process involving several key competencies that can be practiced and recognized within the Metafora platform. Defined earlier in this document, the L2L2 learning performances can be characterized by a set of learning behaviors such as willingness to share, give feedback and reflect, distribute tasks and roles. To this end, the Metafora system allows a smooth interplay between dual interaction spaces (e.g. Mühlpfordt & Stahl, 2007) of the microworlds, the planning/reflection tool and the LASAD discussion tool. Referable objects allow students to make cross-tool reference to objects, and shared resources represented as artifacts allow students to seamlessly move between planning, enacting, and reflecting. These dual interaction spaces serve as an appropriate arena for students' sharing artifacts and ideas along their collaborative work and as such support their L2L2 behavior.

Preliminary insights from our studies (reported in project deliverables[1]) show that the students tend to use the planning tool for reflecting upon their work and concretizing their next steps accordingly. Discourse analysis of the groups' oral discussions (while working with the planning tool) reveal a clear picture of collaborative meaning-making processes over the scientific concepts symbolized in the cards. Moreover, discussions around elements of the visual language and their possible meaning in the context of the groups' work supported processes of L2L2 such as role and task re-allocation, mutual engagement and reflection.

Structure of the demonstration

The demonstration will be divided into three parts. In the first part (15 minutes) we will present the pedagogical concepts behind our work and introduce our pedagogical approach to L2L2. Next we will devote 10 minutes to introduce the Metafora tool. In the third part (30 minutes) we will invite the participants to work in groups and solve a challenge in science (a problem related to kinematics) with the use of the planning tool and a microworld in Metafora. Participants will be asked to work collaboratively on their plan and devise a solution with the use of the microworld. In the final part of the demonstration (15 minutes) we will conduct a reflective discussion on the affordances of the Metafora tool and its aim to support L2L2.

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[1] Metafora public deliverable D3.1 - The scenarios, the microworlds and a descr. of the research design (2012) . Via http://www.metafora-project.org/index.php?option=com_content&view=article &id=33&Itemid=50

GoCivics—Tablet-Enhanced Role-Play Games: A Demonstration

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Abstract: In this demonstration session a novel digital approach to traditional educational role-plays will be demonstrated. *GoCivics Congress* is a tablet-enhanced role-play game that introduces middle school social studies students to the process of negotiation in a US Senate committee and provides practice in listening and public speaking. The game is the prototype for a larger project, *GoGames,* a set of games that represent a novel use of tablets—multiplayer, augmented *social* reality—that streamlines the process of implementing time-tested pedagogical models such as model legislatures, mock trials, and structured debate. Session participants will view a video about the prototype's development and pilot testing in middle school classrooms. A subset of attendees then will be invited to play test *GoCivics Congress*, and will join presenters in a panel discussion of the game and its uses.

Figure 1. *GoCivics* Mobile Congress Title Screen

The Purpose of *GoCivics*

A fundamental assumption of democratic forms of government is that they require the informed and active participation of their citizens. Self-governance depends on citizens understanding how to effectively assess issues, form reasoned opinions, express themselves clearly, and effectively navigate political and legal institutions (National Task Force on Civic Learning and Democratic Engagement, 2012). Citizens who do not understand how or why they should participate undermine the health of a democratic government. A core mechanism for developing informed citizens has historically been formal education. Indeed, one of the early justifications for public education in the U.S. was the development of capable citizens (Dewey, 1954; Merriam, 1934).

Yet in 2010 only 22% of U.S. eighth graders demonstrate "proficient" knowledge on the National Assessment of Educational Progress (NAEP) Civics exam. More problematically, over three-quarters of U.S. middle school students fail to demonstrate even the most basic level of civic knowledge, a pattern that has been noted for over a decade (National Center for Education Statistics, 2011). This is perhaps unsurprising given the relative neglect of civics education in American schools in the last 40 years. Fortunately, this is changing and civic education is "back on the agenda" in the United States (Galston, 2001: 217; Wood, 2012).

One highly effective way to address this "civics gap" is the tried and true method of classroom role plays such as mock trials and model legislatures (Youniss & Levine, 2009). While effective and engaging, these methods are unfortunately time-intensive, administratively burdensome, and difficult for teachers to assess. In the current educational environment in the US—where concepts such as *data-driven* and *standards-aligned* reign supreme—an administratively burdensome activity that fails to clearly address either of these concepts is unlikely to be widely adopted regardless of its pedagogical efficacy.

We suggest, however, that if these traditional models could be made more manageable and easier to administer, they would be more commonly employed. To this end, Filament Games—a commercial game development company that focuses exclusively on developing high quality learning games—is developing *GoGames*, a suite of tablet-enhanced role-play game. The games are structured as a kind of "augmented reality" (AR): digital tools that enhance real world activities with digital information, identities, or actions. Unlike most AR games which hinge on augmenting *physical* reality (e.g., Squire and Klopfer, 2007), *GoGames* are designed to augment *social* reality by providing scaffolding for coordinated role and process enactment.

GoGames products are designed to:

1) enhance students' efficacy and experience participating in role-playing activities,
2) significantly streamline and improve the ability of educators to plan, implement, and assess these activities, and
3) provide school districts with cost-effective but powerful tools for teaching crucial content (e.g., civics) and skills (e.g., listening, speaking, compromise, debate).

We have completed a prototype, *GoCivics Congress*, as a proof-of-concept (see Figure 1). This game has students assume the role of US Senators who are attempting to craft a new bill in a Senate Committee. Players are challenged to balance individual values against the interests of the group, while honing skills of persuasion and public speaking. The targeted pedagogical goals align with Common Core "Speaking and Listening" Standards for 7th grade (Common Core State Standards Initiative, 2010), while the game's structure draws on the Argumentation-Based Computer Supported Collaborative Learning (ABCSCL) model by "[supporting] the sharing, constructing, and representing of arguments in multiple formats" (Noroozi et al. 2012).

Contributions of the GoGames Approach

In each simulation, students take on different roles in the targeted process. Each role performance is informed and structured with on-time, role-specific information, directions, and cues via an app running on his or her individual tablet. By using elements of traditional games such as character roles, stages of advancement, clearly defined abilities and obvious win conditions, *GoGames* provide an easily understandable structure for navigating an open-ended problem space, effectively reducing the player's cognitive load and making it easier for them to engage with the content and each other (Mayer & Moreno 2003). Instructors are provided with an allied app providing oversight and pacing tools, grading modules, and real-time chat functions for private communications with individual students during the simulation.

Unlike traditional video games *GoGames* do not aim to fully immerse students in an alternate digital world. They are multiplayer experiences that naturally scaffolds *direct* interaction among students in the real world. Players do not control an avatar on the screen; rather, they *become the characters themselves* and are able to interact face-to-face, but with their knowledge and goals augmented and supported by the unobtrusive mobile technology. This engenders "improved activity awareness and coordination, [and] improve[d] communication efficiency by enabling non-verbal communication such as gestures, and facilitate grounding via a shared visual reference" (Wallace et al. 2009, p. 569). *GoGames* enhance learning for students by providing role-based, just-in-time and on-demand information while focusing students on the relevant choices to be made based on their role. For example, a student playing a witness in a mock trial is provided with material relevant to his or her testimony while a lawyer sees the rules of evidence and suggestions for witness questions. The game's use of multiple tablet touchscreen interfaces offers a distinct collaborative advantage over traditional single terminal computers by naturally facilitating activity "in a collaborative and communicative way" (Mostmans et al. 2012, p. 105). Each student controls his or her own tablet and are able to view the actions of their fellow students in real-time on their tablet. According to Szewkis et al. (2009) this type of Single Display Groupware (SDG) is especially useful for developing collaboration between members of a large group and leads to greater participation and student engagement. Thus, *GoGames* provide the appropriate supports for a rich, group-based exploration of important civic functions.

A core goal of the *GoGames* solution is to maximize teacher usability by removing the traditional challenges of an in-class simulation. *GoGames* scaffolds the simulations, keeping all students actively engaged throughout the activity, encourages and structures student interaction, and provides teachers with a dashboard in which to set up, manage, and assess the activity. This frees the teacher to focus on instruction, rather than facilitation and management. *GoGames* apps also provide tracking of student interactions within the simulation, efficient and effective grading rubrics, peer-evaluation components, and seamless integration of these components in an easy-to-use (and easy-to-export) data format. By providing automatic scaffolding, keeping all students actively engaged throughout the activity, and providing teachers with a dashboard to help set up, manage, and assess the activity, *GoGames* removes obstacles to traditional simulations and lowers the barrier to more widespread use of these best-practice teaching techniques. *GoGames* tools should be usable with minimal training and administration, a crucial feature where time and money are scarce.

Given research on the effectiveness of traditional educational role plays, epistemic games, and augmented reality museum games, we hypothesize that using *GoGames* will lead to improvements in student motivation and engagement, and significant gains in civic knowledge and skills (such as argumentation and active listening). In the context of a tablet-enhanced, simulated civic activity, students can experience a specific

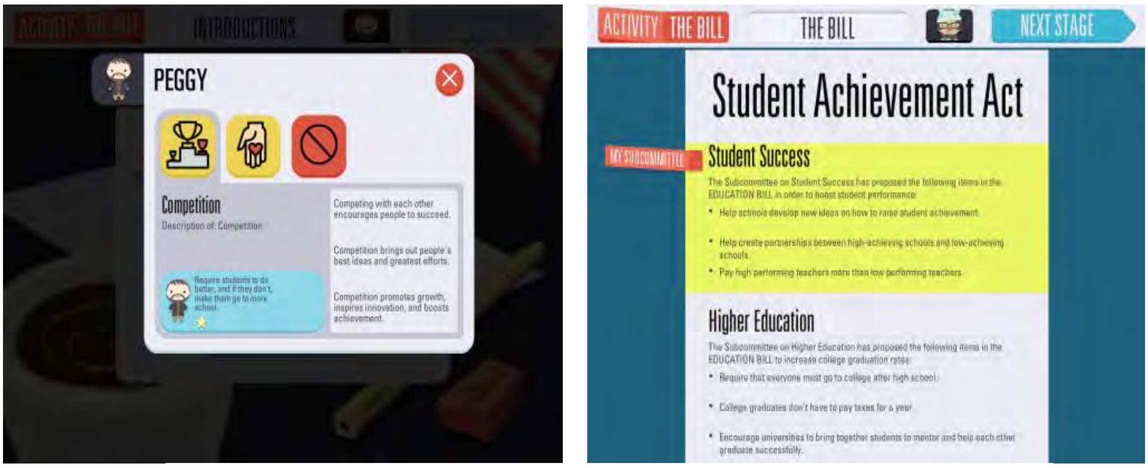

Figure 2. *GoCivics* Congress: Selecting values, the draft bill, and info bar

civic issue, how civic systems function, personal investment in civic participation through role-play, and collaboration and competition across defined roles. That is, GoGames allow players to "connect academic content and practices with students' physical, lived worlds" (Squire and Klopfer 2007, p. 371). In doing so, students will construct a sophisticated understanding of how diverse civic roles interact within a dynamic civic system. As students pursue goals consistent with their roles within that civic system and receive timely, accurate, and customized feedback about their performance, they will develop a deeper understanding of civics and increase their motivation for civic engagement and reasoned debate. We hypothesize that teachers using *GoGames* tools will spend less time preparing for the activity, will exhibit higher levels of confidence, and will experience higher quality interactions with their students. By supporting or automating many administrative, management, and assessment tasks, the simulation will free teachers to focus on providing on-demand coaching and support for students, and on documenting formative assessment of student performance.

The Prototype: How to Play GoCivics Congress

GoCivics Congress invites students to take on the role of a US Senator who is trying, with his or her colleagues, to craft a new bill (see Figure 2). This draft bill is sent to committee and this is where the action begins. Each student-senator takes on sets of contrasting values that influence their motivation for passing particular types of amendments to the bill. They meet in caucus with those holding similar values to craft strategy and to review the proposed amendments. Senators are then assigned to different substantive subcommittees to hash out deals with colleagues who may hold very different values. The subcommittees may

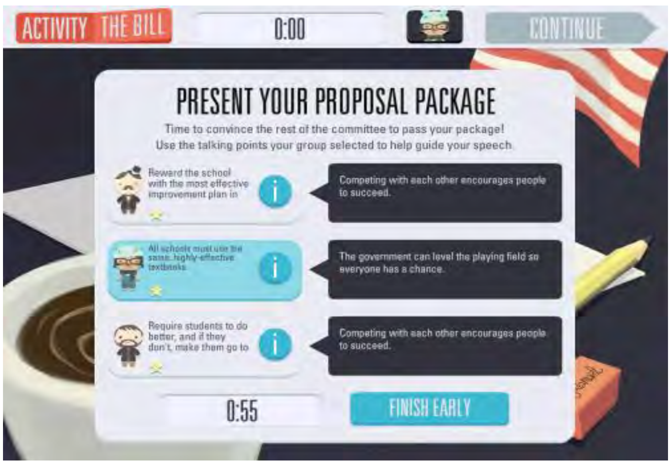

Figure 3. *GoCivics* Congress: Presenting the Package

pass out of subcommittee only a small subset of possible amendments so each Senator must try to convince their subcommittee colleagues to support their amendments or work a deal. Each subcommittee then attempts to convince the larger committee to vote for their package by presenting and defending their package on the floor of the committee (see Figure 3). Players accumulate points based on the values that are represented in the final bill. What if no bill is passed? Everybody loses!

Pilot tests of iterative versions of Mobile Congress were conducted with university students and with three classes of middle school students. These context usability tests demonstrated the feasibility of the technology and the game design. The game effectively supported various forms of discussion and players were actively engaged in the simulation. This data is being used to inform the design of other forms of tablet-enhanced role plays including a mock trial, a structured debate, and a small-scale Model United Nations.

Structure of the Demonstration Experience

The presentation will begin with a video documentary about the creation and testing of the project, including field-testing examples with middle school students. During our demonstration, a subset of attendees will be invited to play through a section of Mobile Congress using iPads while a presenter narrates an overhead projection of the gameplay and the remaining attendees observe. The session concludes with a panel discussion among the playtest participants, and the lead designer and principal investigator of *GoCivics Congress.*

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Studio K: Tools for game design and computational thinking

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Abstract: People need to develop good intuitions about how computation operates within domains of practice (from social software to personalized medicine applications) and how to harness the computer's creative potential. *Studio K* provides an opportunity for young people to develop such computational ways of thinking by designing videogames as part of a virtual studio internship. In this demonstration, we will explore the social and performance feedback mechanisms being designed in *Studio K* to support the development of game design expertise and computational thinking. Pilot study data will supplement the discussion.

Introduction

As digital devices become integrated into more and more facets of our lives, it is imperative that people become literate with digital technologies. This requires more than knowing how to use any particular application or operating system, or even how to program. Instead it requires knowing how to abstract from situations and think computationally (Wing, 2006). People need to develop good intuitions about how computation operates within domains of practice (from social software to personalized medicine applications) and how to harness the "protean" power of the computer: creation. If understanding computation is valuable, using computation to build something personally meaningful is quite possibly the best way to get there. Computational thinking (National Academies, 2011; Wing, 2006) describes an ability to answer the question, "What can I build to understand and/or solve this problem?" Rather than promoting a continued consumption of media, a strong understanding of computational thinking creates active participants in media – changing focus to production and encouraging interest-driven use of media (Brennan & Resnick, 2012).

Unfortunately, learning this way of thinking can be difficult, and there are many intimidating challenges that arise for people looking to develop these skills. There is very little instruction in the US that teaches students how to apply computational thinking, especially outside of the context of programming. Computer science is rarely taught in high schools, and, when it is, emphasizes disconnected abstract principles that create powerful barriers to entry for a potentially diverse audience (Camp, 1997). Pulimood and Wolz (2008) suggests such barriers could be addressed through a pedagogical shift that includes 1) authentic inquiry through creative design, 2) collaborative work mirroring modern media practices, and 3) multidisciplinary approaches to content. *Studio K* demonstrates how incorporating the pedagogical shift described above in order to create video games, and then extending it with real-time performance feedback for both designers-in-training and their mentors can make computational thinking more concrete and more accessible,. In this demonstration session, participants will explore *Studio K* and engage in discussions of the social and performance feedback mechanisms designed into the experience. Data from seven pilot implementations will illustrate these discussions with the capabilities and needs of children in afterschool and classroom settings.

Significance of the Tool

While online games generally offer a vast array of literacy practices and reciprocal apprenticeship (Gee, 2003; Steinkuehler, 2004; Black & Steinkuehler, 2009; Black, 2008), becoming a game designer means going beyond technical creation to craft aesthetics, interactions, and stories that motivate users to play. As other programming and design environments, such as Alice (Pausch et al., 1995), Toontalk (Kahn, 1996), AgentSheets (Repenning, 1993), and Scratch (Maloney et al., 2010), have shown, a) providing an ever-growing reference collection of fun games to be deconstructed and built upon, b) enabling peers to help one another to progress in skill from beginner to expert; and c) creating safe spaces to learn to program together without fear of harassment or judgment (Resnick et al., 2009) can be powerful supports for learning to think computationally.

In *Studio K*, young people take on the role of a videogame designer participating in a virtual internship, working individually and collaboratively to design videogames using the 3D game design application *Kodu* (see

Figure 1). Working in *Kodu* (MacLaurin, 2009), designers play, revise, and create games as they navigate a series of design challenge missions targeting fundamental concepts distilled from the rich literature on videogame design (Anton, Ochsner, Squire, 2013; Kane et al., 2012).

Figure 1. On the left, the Studio K curriculum interface,
In the middle, the initial Kodu interface and design environment.
On the right, programming tiles in Kodu.

While much of the designers' time is spent within *Kodu* designing and creating games, those experiences are contextualized and scaffolded through interactions in the *Studio K* site, where designers engage in professional practices such as playtesting, writing reviews, and iterative design. As they progress through the missions, designers are exposed to increasingly complex models of games and presented with frequent opportunities to develop and share their expertise through community forums and peer reviews.

These social feedback activities are designed to foster a sense of community and mirror the vital practices of successful game developers. As these interactions occur, designers-in-training can develop a richer use of specialist videogame language, an emerging culture of critique, and academic literacy in reading and writing (Peppler, Diazgranados, & Warschauer, 2010; Peppler & Kafai, 2007). These practices promote the designer's agency in design work; designers learn to express opinions, provide justifications, and maintain autonomy in their views even after discussions with their peers (Peppler, Diazgranados, & Warschauer, 2010). These activities also support design processes rich in debugging, iterative design, and feedback, skills central to computational thinking practices (Denning, 2003) which have been observed in use during game play (Berland & Lee, 2011).

In addition to social feedback, designers-in-training can develop their expertise through the choices they make during the design process itself with the aid of learning analytics. As designers create games within *Kodu*, all of their activities are gathered and sent to a database in the site. Research on *Studio K* is investigating the computational thinking practices occurring during game design, as seen in clickstream data, and how learning analytics can be used for mentor- and designer-in-training self-assessment in the site to provide richer experiences. While there are myriad computational thinking practices (Denning, 2003), our initial focus is on debugging, logic, and feedback as previous work suggests their prevalence within game use and design (Berland & Lee, 2011; Stolee & Fristoe, 2011; Brennan & Resnick, 2012). The analyses of these activities are through the lens of analytics on professional programming (Johnson, 2007; Kou, Johnson, & Erdogmus, 2009) to better understand how modifications to these methods can be applied in an educational setting with live embedded feedback.

For example, using a preliminary examination of pilot clickstream data and qualitative observation, we are investigating *debugging* as a computational thinking construct mappable to particular patterns of choices within *Kodu*. Debugging is the act of determining the cause of a malfunction or error (Berland & Lee, 2011). In *Studio K*, we operationalize *debugging* as sequences of *design* or *programming* types of player actions, followed by player actions categorized as *play*, succeeded by additional *design* and *programming* actions. Figure 2 shows a prototype visualization for monitoring *debugging* cycles.

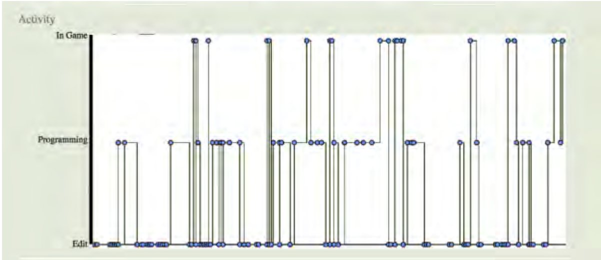

Figure 2. Studio K visualization of Kodu activity.

Pilot studies we are conducting are investigating this mapping of raw clickstream data to higher level constructs to try to better understand such questions as whether the period and frequency of such cycles might provide a good indication of emerging design skill − do they vary with the difficulty of different design challenges? Do designers-in-training demonstrate significant changes in the rates of these cycles from early to later challenges? We are also interested in whether and how such cycles might relate to other performances during the virtual internship, such as designers' reflections on their own designs and on their peers' designs, as well as to learning outcomes measured before and after the experience. And more generally, we are interested in examining (and discussing during the demonstration session) questions like What are the social mechanisms that engage youth in advanced gaming practices that might be leveraged more broadly? What kinds of collaborative tools and data reporting tools for designers-in-training and mentors lead to deeper participation?

Our ultimate goal is to use such measures to drive visualizations within the Studio K website to provide powerful feedback for designers and mentors. The integrated performance and social feedback mechanisms should provide for a rich learning experience both in game design and computational thinking. Students learn increasingly complex programming concepts that are applied within a range of game design situations. The program offers a unique framework for learning programming and computational thinking practices through the lens of game design learning goals. Rather than restricting students to focus on the abstract principles conventionally taught in computer science courses, opportunities for learning are opened to allow interest and creativity to guide activities through curricular participation. As a result the learning focus more strongly emphasizes understanding and application of game design principles through which other skills will be gained. Through these experiences, students should gain autonomy and agency as videogame designers and fluency with valuable computational thinking skills. As *Studio K* develops, it offers a unique opportunity for youth to observe their development and track their progress in interactive, meaningful ways. By further understanding and modifying the methods of analysis applied to professional programming activities, we gain further understanding of how creative technology uses are beneficial to youth and how these practices can encourage larger computational thinking practices. Though these tools are still works in progress, their use has interesting implications for the use of self assessments and usability of learning analytics to support the development of computational thinking for a broader audience than is currently the case.

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iSocial Demo: A 3D Collaborative Virtual Learning Environment

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Abstract: iSocial is an innovative 3D Collaborative Virtual Learning Environment (3D CVLE) to provide access to educational programming for special needs students who live in small and rural school districts. The demonstration will show an implementation of iSocial to develop social competency for students who have been identified with Autism Spectrum Disorders (ASD). The demonstration will focus on aspects of iSocial designed to support social interaction, encourage pro-social behavior, and foster social learning.

iSocial Demonstration

Our demonstration has 4 objectives:

1. Show the iSocial 3D CVLE learning environment so that the audience participants can envision the learning experience of students in iSocial. We will do so by setting up a session with partners back in Columbia so that the audience can see the live environment. This live part of the demo will walk through several of the learning contexts designed to support collaborative learning, such as in the hull of the pirate ship where students need to work collaboratively to identify items to take to the island.
2. Highlight and show key innovations for supporting the social and collaborative experience in iSocial. This will include orthotics for student social behavior such as pods and learning spaces and mechanisms for the teacher to observe and manage behavior such as Live Images and a Token System.
3. Show through video clips students participating in a few key lesson sequences.
4. Discuss the demonstration so as to answer questions and engage issues brought up by the audience and to learn from the audience about their perspective and thoughts for development, implementation and research.

Website: iSocial.missouri.edu

Purpose of iSocial

Small and rural schools are often limited in the range of educational programming they can offer and in the expertise of their teachers to deliver specialized educational programming. Distance Education (DE) is a growing phenomenon in these schools as a means for meeting student needs for courses such as foreign languages and advanced placement. A 2005 survey (Hannum et al., 2009) conducted by the National Research Center on Rural Education Support showed that 85% of surveyed districts had used DE and identified DE technology as a key strategy (nearly 10 million students attend rural schools) to provide a full range of courses and to overcome difficulties in attracting and maintaining qualified and experienced teachers. Unfortunately typical DE is limited in how it provides support for affective and social learning which is often critical to addressing students with special needs.

3D Collaborative Virtual Learning Environments (3D CVLE), as implemented in iSocial, have potential for addressing the needs of small and rural districts for DE programming that brings students together for peer interaction, experiential learning through collaborative effort, and guidance by an expert teacher. The iSocial implementation to be demonstrated is a translation of a curriculum (Social-Competence Intervention for Adolescents, SCI-A) with demonstrated efficacy for developing social competence for the target population of youth between 11 and 14 years of age with a diagnosis of ASD and an IQ of 75 and greater (Stichter, et al., 2012). Our team has translated the program that is typically delivered in face-to-face, small group (4 to 6 youth) sessions into a form that can be delivered over the Internet so as to enable participation by youth who do not have ready access to such interventions in their local schools and communities. In the process of undertaking this translation our team has designed solutions (1) for assuring fidelity between the 3D CVLE experience and the cognitive and behavioral processes and objectives of the face-to-face curriculum, and (2) for encouraging, supporting and sustaining appropriate social behavior and interaction in the virtual world, especially considering that our target students have social limitations.

iSocial Implementation

The iSocial VLE for developing social competence delivers the SCI-A curriculum via 34 lessons of 45 minutes each with lessons scheduled for 2 to 3 times per week which is consistent with delivery of the face-to-face version. The lessons are packaged in 5 curriculum units: facial expression, sharing ideas, turn taking, feelings and emotions, and problem solving and delivered in a series of 3D virtual worlds. Figure 1 shows a top view of the 5 worlds.

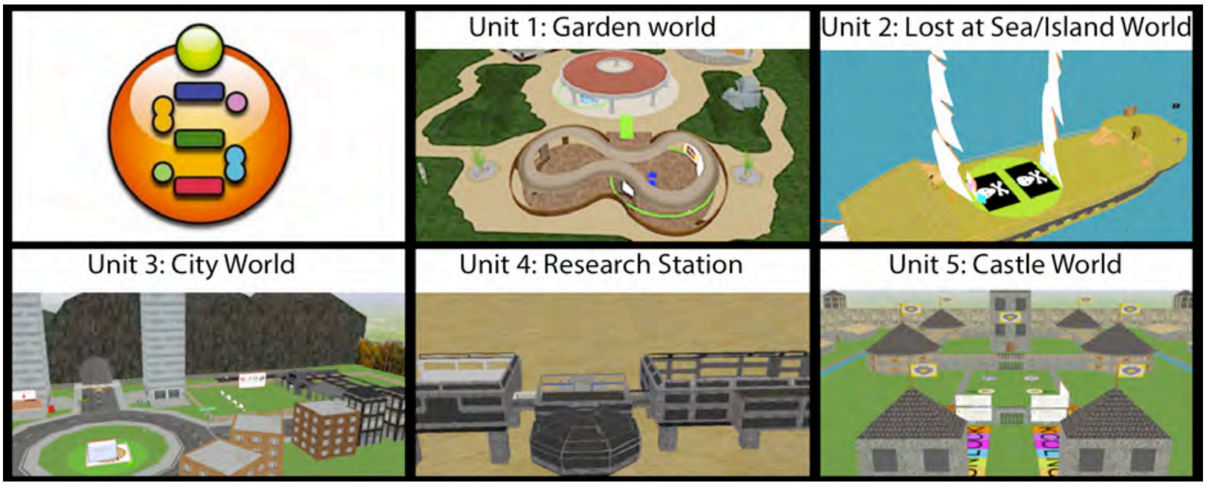

Figure 1. iSocial worlds across the five curricular units

Students are represented in the world as an avatar that communicates primarily through audio but also with text and gesture. Through these communication mechanisms iSocial attempts to provide the essential opportunities for synchronous learning with the teacher and peers to match what can be experienced in the face-to-face classroom. The learning experiences are delivered through a structured sequence that moves from teacher-directed introductions, to modeling, to structured practice, to naturalistic practice and then review. In addition, the VLE provides multiple additional real time experiences and affordances with materials not available in standard face-to-face learning. To provide a sense of what the learning experience is like, the following scenario briefly depicts the experience of a youth participating in a lesson activity. We have selected the "Lost at Sea" activity from the third lesson of unit two which has a goal of teaching the students to identify and apply the role of speaker and listener in order to better share ideas. By the time the youth gets to this activity, the youth is well oriented to his group of three to five peers and his teacher, who we call the online guide (OG), as well as to the general methods and tools of iSocial. We start with the OG providing positive feedback to the group on completing the prior activity and asking them to move to the area where they will decide which roles they will take on for the upcoming "Lost at Sea" task (see Figure 2).

Figure 2: On the left is the ship where students undertake the lesson. On the right, students and the Online Guide gather in an area on the ship to discuss their roles for the upcoming activity. Students get guidance for carrying out their role by standing on the colored pod.

After having spent several lessons on the ship, students are told that the ship is sinking. Their mission during this lesson is to decide on roles for each member, collectively decide on which eight (out of 15) items to take with them, escape to the rescue boat while negotiating which part of the island is best for their survival, and arrive on the chosen part of the island. The lesson is designed to require discussion and negotiation among the students through activities that the OG facilitates to build students' social competence accessing targeted curricular-based skills. The OG facilitates the students' choosing their roles such as "items task manager" and "location manager for the campsite." The students negotiate who will do what, and why they think they should have a certain role of their choosing.

After the role selections are completed, the OG leads students into the cargo hold where they choose items to take with them to the island. Each student must express what they think would be good to take and why. Disputes over what would be most important to take with them to the island lead to the negotiation of agreed-upon items and their worth on a deserted island. The timekeeper warns the team to get to the rescue boat because the ship is sinking. As they decide upon items, the items disappear from the environment and appear in their inventory. The team hurries to negotiate quickly and make final decisions, after which they escape to the rescue boat. The next activity begins with the students discussing the pros and cons of locations on the desert island while continuing to practice the roles of speaker and listener.

Unique Approach and Attributes of iSocial

Over the past 10 years a number of projects have been developed in the 3D CVLE genre with some of the most significant being River City, Quest Atlantis and EcoMUVE. River City is a multi-user 3D VLE developed for middle-school students to learn skills of hypothesis formation and experimental design as well as content related to national standards and assessments in biology (Clarke et al., 2006). Quest Atlantis is a set of multi-user 3D VLE for knowledge quests and interactive tasks for learning through transformational play (Barab, Gresalfi & Ingram-Goble, 2009). EcoMUVE (Metcalf, Clarke & Dede, 2009) is a multi-user 3D VLE implemented as a two-week module focused on teaching students complex causality in ecosystem environments. Each of these systems demonstrates that 3D VLE is engaging and shows some promise for impacting student outcomes. However, they differ strikingly from the implementation of iSocial (Schmidt, Laffey & Stichter, 2011; Laffey et al, 2009a). These systems emphasize individuals performing certain tasks in a world and reporting back to peers or an instructor using text chats or written submissions. Interactions are typically multiple choice and with non-player characters or objects in the world. Typically these systems are implemented in classrooms while supporting and encouraging interaction and collaboration with classmates and teachers outside the virtual world. In contrast iSocial is designed so all the learning activity and social interaction take place in the virtual world and the teacher is a character in that world rather than a presence in the physical classroom. This configuration is part of our design because our delivery model envisions youth across a number of rural school districts coming together in an iSocial course, where the only contact point is through the virtual medium.

In order to implement a virtual world that facilitates audio communication and supports co-presence of members we built iSocial using Open Wonderland, a Java-based open source toolkit, for creating virtual worlds. Using an iterative design research approach we have explored, tested and eventually settled on designs for a number of mechanisms that support being social and being on task for the students and behavioral management for the OG (see figure 3 for a sample screen for the OG showing numerous mechanisms for managing the course and student behavior).

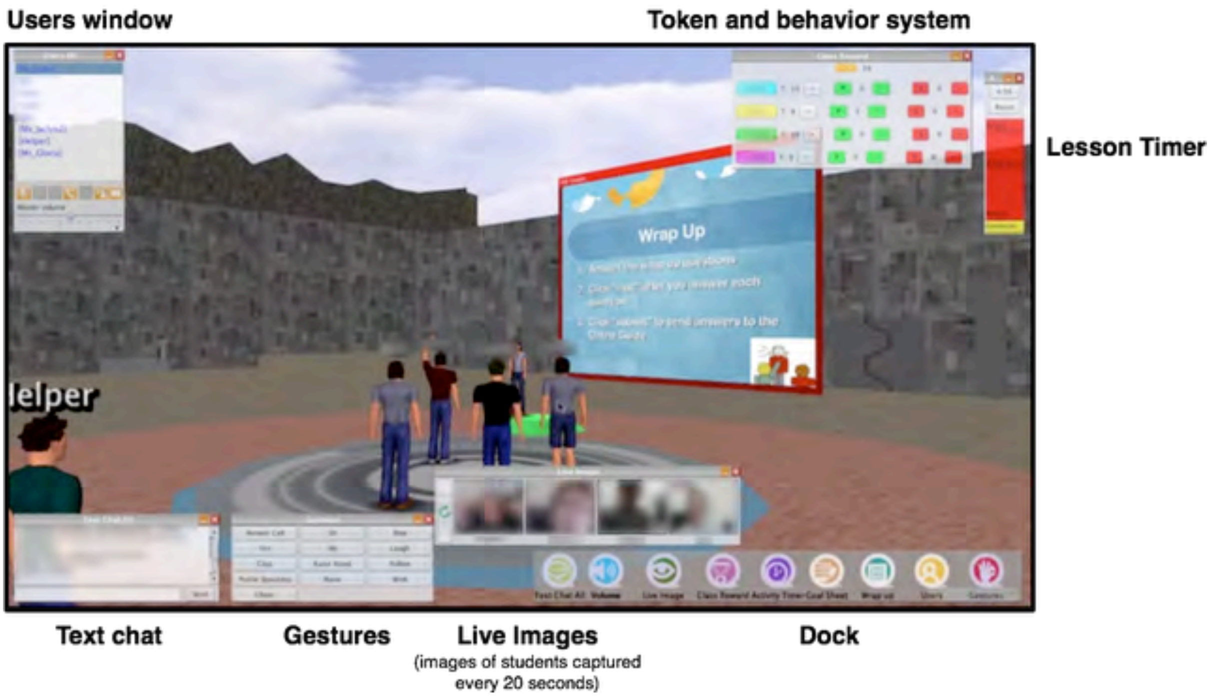

Figure 3: The OG interface includes the text chat, gestures, live images, dock, lesson timer, token and behavior system, and users window. The OG dock has access to items that the student does not. The student view has dock, visual tokens and strikes, gestures, and chat.

We worked systematically through five units with each unit representing our best ideas and capabilities at the time, and then through a usage test of the unit to teach us how to improve both our ideas and capabilities. At the conclusion of the five units of development each unit was upgraded as appropriate. Our team created many new innovations and customized the features of Open Wonderland to optimize our curriculum translation. See *http://bit.ly/isocial-functions* for a description of many of the key technology innovations. Some notable examples of innovations from this outline include:

1. The Media Board is a white-board for displaying and interacting with multiple forms of media in the virtual world and includes allowing students to take pictures of themselves with a webcam, such as when displaying a facial expression, for sharing with the online guide (OG) and peers. The student, OG and peers can then discuss the images and arrange them on a continuum so as to give feedback to the student.
2. Pods, Spaces and Barriers have been developed as behavior management devices (we call them social orthotics) (Laffey et al, 2009b; Laffey, Stichter & Schmidt, 2010) to aid the OG in managing individual and group behavior during lesson activities. These devices act like furniture to invite students to move to appropriate places and orientations and also can be secured to prevent unwanted distractions during lessons.
3. Live Images is a device for helping the OG manage and facilitate behavior. Before Live Images the OG could see avatar movements and listen to the student talk, but did not have any visual cues about the physical presence. Live Images gives the OG a snapshot of each student every 20 seconds as well as on-demand so as to monitor physical behavior. Full video streaming would be too great a drain on network resources but every 20 seconds seems to be a good compromise between technology concerns and behavioral concerns.

While there is still much to learn and numerous challenges to address the iSocial design and implementation identifies a new form of computer support for learning that depends on high quality collaboration between students and teachers and among students. This form of CSCL seems highly relevant for addressing special needs populations that not only need high quality learning opportunities, but teachers with specialized knowledge and training to overcome barriers to students engagement and performance in learning situations.

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DynaLogue: Teacher Candidates Collaborating to Learn and Teach Proportional Reasoning

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Abstract: DynaLab is an interactive, Web-based resource for teacher educators to use with beginning teachers, helping them learn to teach mathematical reasoning. This demonstration focuses on one aspect of this hands-on curriculum, DynaLogue. Participants will collaborate to compose simulated dialogues between a hypothetical student and teacher, including a whiteboard to draw and write visual representations. They will discuss and share their ideas for how to understand student thinking around a proportional reasoning problem, thus building a repertoire of explanations and broadening their knowledge of how to teach complex mathematical ideas.

Purpose

DynaLab is an interactive, Web-based curriculum for teacher learning. Teacher candidates use this hands-on curriculum when taking courses needed to complete their training as teachers. (Hereafter, we use the term “candidates” for university students who are preparing to be certified as a K-12 teacher). The purpose of DynaLab is to help candidates learn more about how to develop students’ mathematical reasoning, and particularly, their proportional reasoning. In service of this purpose, the DynaLab exploits capabilities that are unique to the digital medium.

Instead of the traditional chapter structure of a textbook, the DynaLab is organized in a five by three matrix (see Figure 1) covering three proportional reasoning domains (ratio, geometric similarity, and linear functions), and offering three opportunities for engaging with each domain (interactive lessons with dynamic representations, video cases of students reasoning through problems, and context-rich problems to try themselves). This feature enables university instructors to customize the use of DynaLab.

Within each category, DynaLab includes dynamic learning tools to engage candidates in collaborative learning. One tool focuses on candidates’ learning of mathematics content. An individual candidate often has difficulty thinking of more than one way to solve a mathematics problem. However, a classroom of candidates often comes up with many strategies. The multiple modes of responses and “shared work” tool allows each candidate to use multiple representations to share their solutions: text, drawings, uploaded photos, recorded audio, and their demonstrations with interactive tools. These varying solutions can then be compared by the instructor in a shared workspace, which can lead to very good discussions among future teachers – how can teachers avoid the misconception that there is only “one right way” to solve a math problem and instead make sense of varying strategies?

Another tool, called DynaLogue, enables candidates to write simple dialogues in which they envision how a teacher and a student would interact so that the student’s mathematics reasoning becomes stronger (see Figure 2). The dialogues are synchronized with a whiteboard between the virtual participants, because mathematical reasoning often involves drawing and gestures linked with talk. Collaboratively writing DynaLogues is a powerful activity in which candidates can share their mathematical thinking, practice pedagogical ideas, and engage in constructive criticism.

Overall, the tools within DynaLab are designed to help candidates make judgments about students’ proportional reasoning and how to work with students to improve this reasoning. This requires building teacher candidates’ pedagogical content knowledge (Shulman, 1987) in proportional reasoning, increasing their confidence about how to teach these concepts, growing their appreciation for mathematical reasoning, leading them to use precise language when explaining concepts to students, and helping them to build on what students do.

Theoretical Frame

The DynaLab project helps teacher candidates make judgments about student’s ideas of proportional reasoning and how to work with students to clarify and correct them. The DynaLogue tool was designed under the two theoretical frameworks of Universal Design for Learning (UDL; Rose & Meyer, 2006) and Technological Pedagogical and Content Knowledge (TPACK; Mishra & Koehler, 2006). UDL is a set of principles that consider alternative ways for students to engage with curriculum, to learn through multiple representations, and to demonstrate what they know. DynaLab explicitly teaches the principles of UDL and also incorporates them into the design. For example, DynaLab uses multi-modal response spaces where candidates can type, use digital interactive manipulatives, draw, record, or upload a response. One such manipulative is a ratio bar visualizer. Candidates can represent a ratio in red parts to blue parts and then split the display to see if another ratio is equivalent.

Shulman (1987) defined pedagogical content knowledge as the professional understanding of teaching, or "how particular topics, problems, or issues are organized, represented, and adapted to the diverse interests and abilities of learners, and presented for instruction" (p. 8). TPACK is an extension of Shulman's (1987) conceptualization of pedagogical content knowledge, combining technological advances with knowledge required to teach specific content (see Mishra & Koehler, 2006). Candidates build a deep understanding of how to teach proportional reasoning by incorporating technology into building their own knowledge. They create digital representations and model pedagogy by creating DynaLogues to teach challenging content to a hypothetical student who harbors deep misconceptions.

Contribution

A globally important transition from print to electronic textbooks is occurring. This demonstration contributes by showing one way to re-imagine the role of the textbook in a particular context – the teacher education context. We will demonstrate a resource that started with the concept of an "electronic textbook" for teacher education courses but became an interactive environment where teachers collaborate to increase their math knowledge, to develop their strategies for working with students, and to become familiar with constructivist technology for learning mathematics.

Further, this demonstration closely aligns with the theme of the conference, learning across space, time, and scale. DynaLab and its many components, including DynaLogue, create opportunities through innovative technology to spark dialogical learning across three levels: (a) teacher educators, (b) teacher candidates, and (c) their students.

Empirical Support

DynaLab development involved collaboration among researchers at SRI International, UDL designers at CAST, special education teacher educators at San Francisco State University, mathematical teacher educators at San Diego State University, and project evaluators at Inverness. They used a design research approach to collaborate and develop progressively more interactive, collaborative iterations of this resource.

Design Research

Schoenfeld (2006) presented several definitions for design research. He acknowledged that design experiments manipulate multiple dependent variables "in the messy situations that characterize real life learning" with flexible design revisions (p. 200). During this project, data collection has been ongoing during the three years of developing DynaLabs. For example, at San Francisco State University, researchers have been designing lessons using DynaLabs during a student teaching seminar offered every semester. They presented DynaLab versions to one or two classes each semester and collected data from surveys, assessments of pedagogical content knowledge, video observations, and lesson plans written by teachers after DynaLab lessons. At the end of its development, data will be reevaluated systematically in a retrospective analysis and serve to build a set of claims into a coherent theory. Through the design process, DynaLab was changed from a text-heavy, linear website to an interactive, content-rich resource that includes collaborative discussions of different ways of thinking about proportional reasoning.

Findings

Findings from two pilots at San Francisco State University and San Diego State University will be discussed next.

Study 1

DynaLabs was presented to 17 special education teacher candidates during two, three-hour lessons at San Francisco State University. Participants in these lessons significantly improved their scores on a measure of pedagogical content knowledge, $t(16) = 2.72$, $p < .05$, with a moderate effect size (Cohen's $d = .44$). However, overall scores at pretest were 10.65 ($SD = 6.21$) or 34% correct and posttest ($M = 13.12$, $SD = 4.95$), or 42%.

Surveys indicated that the class activities were engaging (particularly creating teaching scripts, small group discussions, and problem solving). Candidates reported that they learned *some* or *a lot* about ratio (65%), UDL (55%), using technology for teaching (55%), student thinking (50%), and their own understanding (55%). Class observations suggested that videos of student thinking were particularly motivating and anchoring. By the final class, candidates were observed to engage in extended discussions about mathematical reasoning. These analyses revealed that

- DynaLab's usefulness in preservice education relies on the ease of expressing mathematical thinking and reflections in DynaLab. DynaLab uses short videos and tutorial scripts to *dramatize the practices of mathematical thinking* in ways that are directly relevant to how middle school teachers interact with middle school students and provides dynamic representations to exemplify how technology can support deeper mathematical thinking.
- Although these dramatizations can be somewhat idealized, it is critical that preservice candidates can *suspend belief* and treat the expression of mathematical thinking in DynaLab as exactly what they might with real students because this both generates a high level of engagement and creates the potential for usable mathematical knowledge for teaching.

Study 2

At San Diego State University, various tools within the DynaLabs including the DynaLogue activity were enacted with two sets of preservice teacher candidates who wanted to specialize in middle school mathematics. Analyses of the resulting DynaLogue videos focused on documenting the degree to which this could be used as a tool to reveal prospective teachers' understandings of the (then new) Common Core State Standards and the eight associated Mathematical Practices. These analyses revealed, among other findings, that

- Pre-service teachers were most comfortable identifying and creating scenarios that demonstrate Math practice 1: (Make sense of problems). They were less comfortable with practices 4&5 (Modeling and Tool use). This indicates a critical deficit that we are planning to address in the next iteration of DynaLab tools.
- Use of DynaLogues made Preservice teachers' beliefs about teaching more explicit objects of study. As the students engaged in a *create-share-refine* cycle, they become more comfortable observing others' videos and offering supportive feedback. In this way, they became better skilled at identifying and enacting the various mathematical practices. Reflections on the activity revealed that these teacher candidates felt more prepared to support and predict their future students' discoveries, engage their future students in productive mathematical ways of thinking, and see teaching as an ongoing, multi-faceted process *open to peer review* rather than a private series of unrelated "single shot" lessons that are presented without connections.

Structure of Demonstration

In this demonstration, we will invite attendees to take the role of a candidate who is attending a university course in order to learn how to become a better mathematics teacher.

Simulated Teacher Education Experience

Attendees will experience a simulation of the university courses we have conduct with DynaLab, and will participate using their own laptop. First, they will work in teams to express creative strategies to solving a ratio problem and will be encouraged to describe their solution with multiple representations. They will post these responses to a shared workspace that anonymously showcases each team's contribution. These solutions will spark a discussion with all participants imagining and describing the thinking behind each response. This discussion emphasizes multiple solution pathways and the importance of understanding proportional reasoning conceptually and not relying on a memorized algorithm. After this discussion, participants will watch a video describing levels in proportional reasoning understanding, (a) illogical, (b) additive, (c) transitional, (d) ratio (Khoury, 2002). Then, attendees will watch a short video of a student incorrectly solving this same problem and discuss the student's thinking and stage of understanding proportional reasoning. They will write a script that addresses that student's misconceptions using DynaLogue. Participants will watch each other's DynaLogues and discuss the effectiveness of the hypothetical teacher's approach to working with the student in the video. At the end of these experiences, we will have a general conversation about the potential implications of DynaLab and similar resources to transform teacher training.

Participant Outcomes and Implications

By actively participating in a dynamic learning environment, participants are expected to more deeply understand mathematical content and students' thinking. Discussions act as a model for how to organize lessons around mathematical practice standards found in the Common Core State Standards in Mathematics (2010). It is our hope that participants will begin to value understanding and discussion over just helping students arrive at the correct answer.

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Appendix

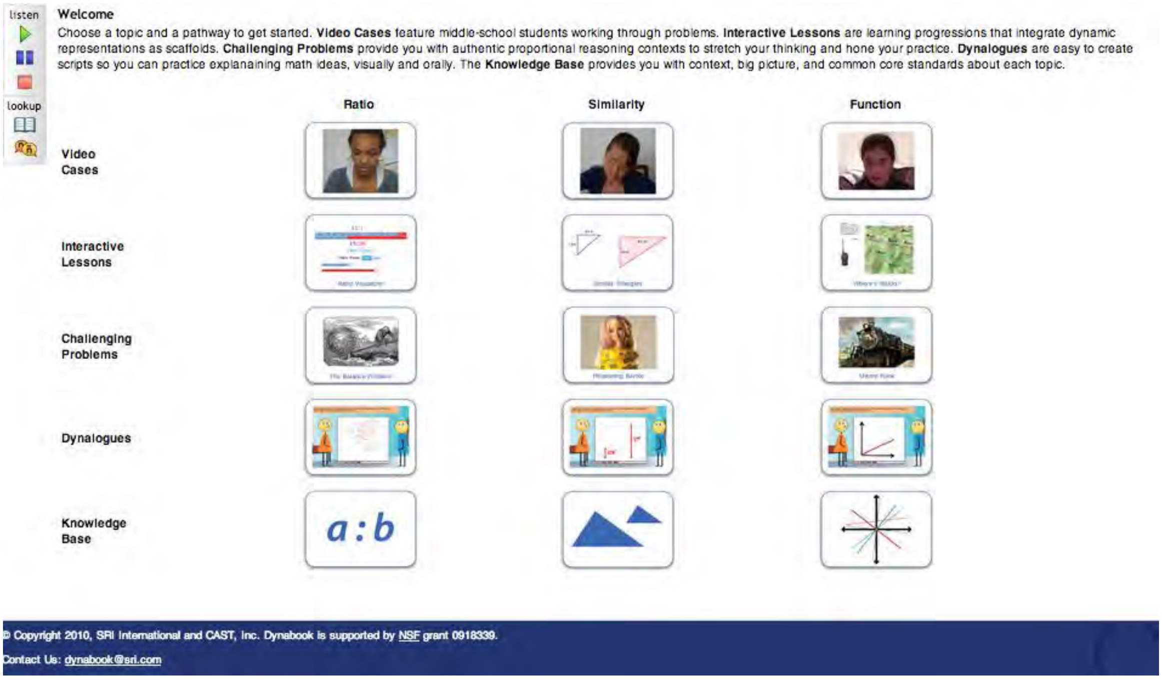

Figure 1. A screenshot of the five by three matrix on the DynaLab home page.

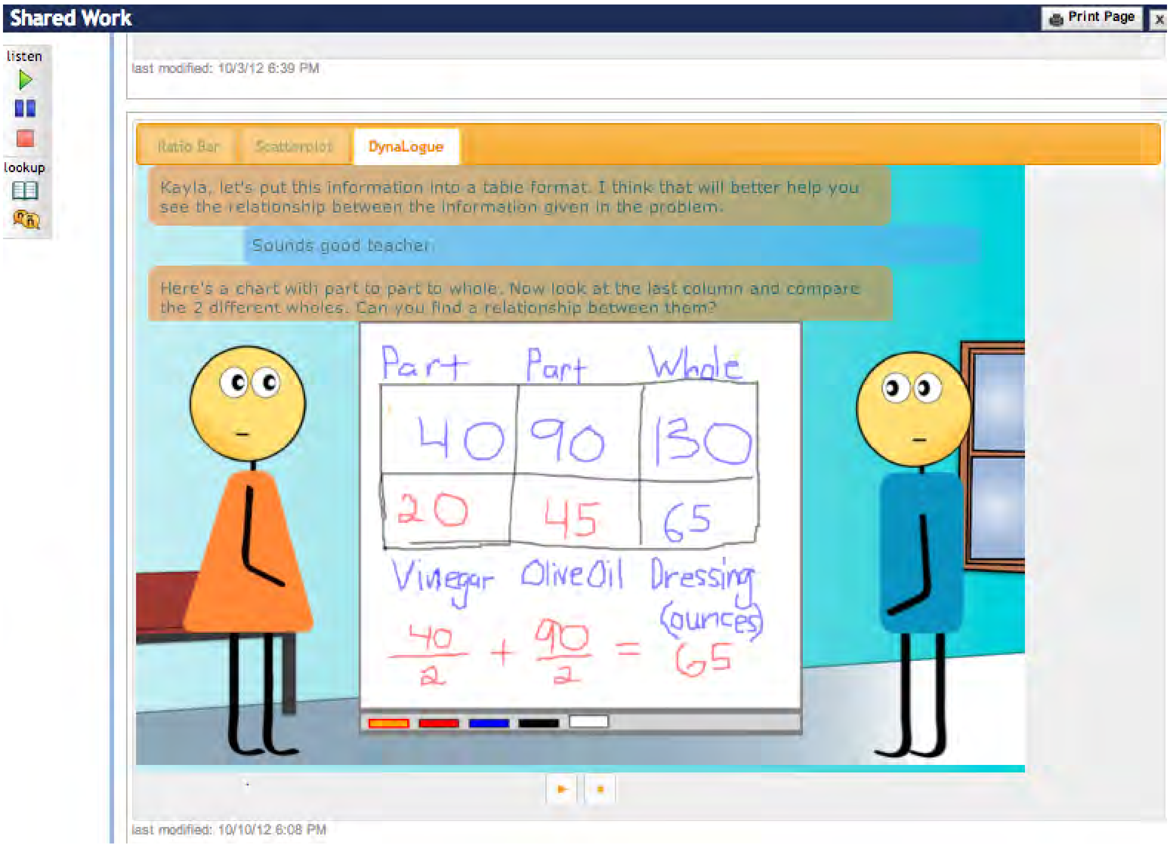

Figure 2. Screenshot of a sample DynaLogue.

CyberSTEM: Making Discovery Visible Through Digital Games

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Abstract: The purpose of this demonstration is to present how video games can communicate cutting-edge science research topics to a new generation of players. Researchers in the Games, Learning, and Society Center (GLS) at the University of Wisconsin-Madison collaborated with partners at the Wisconsin Institutes of Discovery (WIDs) to develop and refine a suite of educational video games to explore topics such as limnology, virology, regenerative medicine, and ecological science rarely studied in the realm of educational spaces. Several games develop collaborative participatory science skills while expanding games based learning into adult informal learning. The presentation will begin with brief history of CyberSTEM implementation, followed with a hands-on demonstration of the iterations in the most current form, and will close with a audience discussion of the direction of CyberSTEM and its social network.

The Project

CyberSTEM: Making Discovery Visible Through Digital Games is a NSF-funded project designed to build science based educational video games, a social network, and learning community that will transform STEM learning experiences and enhance player abilities and interests in STEM fields. It contains three main components: 1) a suite of video games designed to improve player understanding of cutting-edge science research; 2) an assessment model designed to use collaborative game play as evidence for learning; and 3) a social network and distribution environment designed to engage many players in collaborative play and problem-solving.

CyberSTEM games have been designed and developed with researchers from the Games, Learning, and Society (GLS) research center in the Wisconsin Institutes of Discovery (WIDs). The GLS strategy is to work with science research teams to identify the key ideas and techniques in the research domains that would enhance the public understanding of the science. GLS design teams include game programmers, graphic designers, content area experts, and Learning Scientists who determine which aspects of the key ideas lend themselves to interaction in which kinds of game genres. The games are iterately designed and tested, with both content experts, educators, players, and learning scientists, to measure both playability and fidelity of the play model to the content model.

Theoretical Background

The GLS approach to design for learning is anchored in four key concepts: situated learning and cognition, intrinsic motivation, transformational play, and objectives and assessment (Van Eck, 2009; Barab, Greslfi, & Arici, 2009).

Situated learning theory states that knowledge and transferability is strongly tied to context, domain, authentic activity, and culture. Learning is effective when it is presented in a meaningful context. Games embed knowledge, give feedback and guidance, and present instructional events within the context of the game narrative. Intrinsic motivation derives from internal events, such as personal goals and rewards. Learning is maximized when students are intrinsically motivated without external rewards and punishments. GLS designs align and extend the game content (role-playing, fantasy, narrative, and context) to content that is outside of the game (Van Eck, 2009). In transformational play, the player is a protagonist who must use the curricular content knowledge, skills, and concepts to understand a fictional situation and make choices to transform that situation. Transformational play leads to a greater engagement with immersive activities and simulations as students experience accountability and consequentiality (Barab, et al., 2009).

Gee (2005) supports how gaming contributes to situated learning, intrinsic motivation, transformational play, and assessment. He states that educators need to make learning in the classroom and outside of school, more game-like by using these learning principles, incorporated in games, both reflectively and strategically in our practice with or without using games in the classroom. Effective GLS instruction builds opportunities for collaborative application of what is learned with feedback to help the learners monitor their own learning. Indirect and direct communication of objectives are common in the establishment of objectives in games.

The epistemologies of GBL lay a foundation for new forms of assessment, i.e. extending the game play to additional instructional activities and how they are organized by problem and challenge, and comparing them to relevant real scenarios (Schaffer & Gee, 2009).

Gee (2008) argues that gaming can impact learning and assessment. Gaming is one set of collaborative digital tools in the 21st Century Skills toolbox (that includes situated learning and communities of practice). As learning becomes more online, GBL can change the culture and ethic of education to be organized around collaborative learning communities of practice rather than a form of organized top-down social control of students (Squire, 2005).

The Design Challenges

Games for Participatory Science (GPS), developed at WIDs is an approach developed to make inquiry and discovery visible in games. This is accomplished through collaboration with domain scientists, modeling of physical and social scientific systems, position players as goal focused members, constructing of knowledge, and creation of opportunities for participation in authentic science practices (Shapiro & Squire, in press).

The GPS approach seeks to build upon traditional inquiry-based learning with an emphasis on aesthetics and flow in immersive scenarios to foster understanding of science, increase learner involvement and participation in science practice. "Basic research on learning through games (and in learning sciences more generally) emphasizes that much knowledge production, integration, and reflection (often described as metacognition) arises through social interaction" (Shapiro & Squire, in press). By seeking to connect learning through interaction and science practice, CyberSTEM games are not only designed for schools, but also for engaging players in informal learning situations and work settings.

To increase player social interactions, CyberSTEM is building a social gaming network to create opportunities for players to participate in a gaming community. This will allow for new models of engagement and interaction within and across the CyberSTEM games.

CyberSTEM using the GPS approach is fostering engagement, problem solving, and deep critical thinking skills with domain content interest dilemmas, experiences, and user interactions. By concentrating on domain content through the collaboration with the content experts, CyberSTEM designing and developing games for play across spaces and for systems that can scale, attempting to understand learners activity temporally and spatially (B. Shapiro, personal communication, November 8, 2012).

The Games

The CyberSTEM project is developing five games that introduce students and adults to different cutting edge science content and concepts. Video introductions to the games may be found at http://bit.ly/VEanJB.

Citizen Science is an adventure game that teaches limnology (the study of the life and phenomena of fresh water) and scientific literacy. Players travel back through time to uncover and solve pollution problems faced by Lake Mendota. Learning from the past and working together, players address the continuing eutrophication threats and attempt to restore Lake Mendota to conditions suitable for human use. Citizen Science is designed to develop an understanding current ecological conditions and issues. Players learn to use science inquiry and working together to enact change in the legislative process. CyberSTEM supports the iterative development and collaboration in adapting the game for classroom use. Preliminary investigations were conducted of how teachers used the game in their classrooms with different respective pedagogies ("ERIA Interactive - Citizen Science," n.d.).

Progenitor X is a narrative-driven, turn-based, puzzle game in which players assume the role of a regenerative biologist to prevent a zombie apocalypse. The game was developed in partnership with the Wisconsin Institutes for Discovery Regenerative Medicine research team to present core ideas of cutting edge stem cell science in context of a game. Progenitor X players are challenged to cultivate and differentiate stem cells, assemble tissues, and replace organs that have been contaminated with a zombie virus. Game play requires players to solve cell, tissue, and organ puzzle cycles while learning about their relationships and the scientific principles of stem cell research and concepts ("ERIA Interactive - Progenitor X," n.d.).

Trails Forward is a multi-player, turn-based, strategy simulation game that invites players to make ecological and economic decisions about land use in rural Wisconsin. Trails Forward simulates the emergent economic and environmental effects of users' decisions on a robust multi-agent model of land and forest economy and ecology, coupled with human and animal population dynamics. Trails Forward is iteratively designed and developed with extensive input from stakeholders including UW Madison faculty in forest and wildlife ecology and agricultural economics, the Wisconsin Department of Natural Resources, and the Menominee tribe.

Trails Forward allows players to take on roles in buying land and determining land use. Each role emphasizes certain kinds of land use, and is designed to collaborate and conflict in specific ways with other roles. Currently, players may choose the roles of a housing development company, a timber company, or conservation nonprofit. Players learn that each role have competing land management interests, philosophies, and goals. Players develop an understanding of the environmental costs and benefits of their decisions and actions. With each turn, players learn that these roles can hinder or help one another. Game play allows players understand how to make decisions about maximizing scarce resources in contested environments. Game play allows researchers the opportunity to observe collaboration and competition ("ERIA Interactive - Trails Forward," n.d.).

FairPlay is a game designed to give players the opportunity to experience some of the biases encountered by individuals from underrepresented groups in academic science, technology, engineering, mathematics, and medicine. The game invites players to assume the role of a young researcher trying to achieve academic success. As they progress through the game, they encounter examples of bias from peers, superiors, and even strangers, and can reflect on their experiences and try to decrease their own biased behaviors. To complete the journey to renowned professorship, players must successfully operate a university research lab and maintain a diverse collaborative academic social network ("ERIA Interactive - Fair Play," n.d.).

Virulent is a strategy action game designed and developed to teach the principles of virology. Be the Virus! In Virulent, players take on the role of a virus attempting to break into a cell and to take over cell reproductive structures to manufacture more viruses. Players strategize on the proper course of action in infecting, manipulating, and escaping from host cells and their cellular immune responses.

Virulent was designed in collaboration with the Systems Biology research group and faculty from the Medical Microbiology and Immunology department at the University of Wisconsin - Madison. Current research indicates that the engaging game play of Virulent as supplemental curricular material increases the social interaction of students and the temporal relationships in the viral replication process ("ERIA Interactive - Virulent," n.d.).

CSCL Interactive Event

The interactive event we are planning for the conference has several main goals.

- We will showcase the CyberSTEM games, allowing the participants to experience cutting edge science based educational video games in a hands on environment.
- Through video footage and session presenters, you will receive firsthand accounts of the CyberSTEM implementation and the research based iterative process.
- Participants will receive a demonstration of the social network and will provide usability feedback.
- Event participants will be part of a research project and will be able to provide feedback on each of the models.

In the proposed demonstration, we will first describe and facilitate a discussion on the CyberSTEM approach by presenting on the science and game design. Alexander, Eaton, & Egan (2010) suggest that there are three general strategies for educational gaming practices with formal and informal learning situations. The first approach focuses on the skills and abilities that players acquire by playing the games, i.e. analysis, deduction and discrimination. The second approach to game based learning is using games to teach curricular content. The third approach is the transfer of learning. The aim is to structure the content and design of the game to make them engaging for the player in new meaningful ways. Players are engaged and motivated through features such as narrative structure, heroic human qualities, emotion, role-playing, conflicts, and the extreme and the exotic. Participants will discover the intrinsic motivation and behavioral self monitoring of the collaborative transformative play.

Our demonstration will allow participants the opportunity for hands-on interaction to explore our collaborative educational video games. We will feature all five games described above: Citizen Science, Trails Forward, Virulent, Progenitor X, and Fair Play. We will focus on Trails Forward and Fair Play, unique game based simulation models with interdisciplinary content, as examples of expanding GBL into the adult workplace and community decision making/learning space.

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Appendix

CyberSTEM is a three-pronged strategy for designing and developing collaborative educational video games and a social learning network. Our demonstration will allow participants the opportunity for hands-on interaction to explore and discover our collaborative educational video games. We will have five featured games that will include Citizen Science, Trails Forward, Virulent, Progenitor X, and Fair Play.

We will be able to supply the computers to facilitate the demonstration. Special requirements will include a room with the capacity and space to handle up to 30 or more computers. We will need a projector and possibly additional power strips.

Demo of Collaborative Dynamic Mathematics in Virtual Math Teams

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Abstract: Dynamic mathematics software like GeoGebra provides new opportunities for mathematics education. With proper technological and pedagogical support for collaborative dynamic mathematics, it is possible to create a CSCL approach to foster significant math discourse. The demo of the Virtual Math Teams (VMT) online environment will focus on the recent development of a multi-user version of GeoGebra within VMT. To support effective use of VMT, a coherent set of dynamic-geometry activities has been developed; this will be discussed as well as a professional-development course for in-service math teachers, preparing and supporting them for introducing collaborative dynamic mathematics in their schools. Tools built into the VMT software for detailed interaction analysis will be demoed and sample case studies referenced.

Virtual Math Teams: Contribution to CSCL

The Virtual Math Teams (VMT) Project is an on-going design-based CSCL research effort, funded by NSF from 2003-2016 (see Acknowledgements). It has already produced a significant impact within the field of CSCL, with an edited volume in the Springer CSCL series (Stahl, 2009) and many papers published at CSCL conferences and elsewhere. It is in many ways a prototypical CSCL project, including the development of software to support collaboration, a school content focus (mathematics), a design-based approach with cycles of trials/analysis/redesign, an analytic method (a form of interaction analysis, with special tools) and an emergent theory (group cognition (Stahl, 2006)). Previously, VMT has not been demoed at a CSCL conference, only at practitioner conferences like NCTM and ICME or regional and international GeoGebra conferences.

While the importance of collaborative learning for online education is obvious to CSCL researchers and its possible advantages have been well documented in cooperative-learning and CSCL research for decades, support for collaboration is still not always designed into new educational platforms. For instance, the latest hot approach to university instruction—massive open online courses or MOOCs—are generally based on the lecture paradigm, where students passively watch talking-head videos of famous professors and are not given any sanctioned opportunities for interaction. Similarly, the acclaimed Khan Academy offers YouTube videos explaining thousands of detailed topics in school mathematics, but students have no support for exploring the topics themselves or discussing them with peers. These technological opportunities are generally not designed to incorporate constructivist learning principles.

With the development of dynamic-geometry and dynamic-mathematics software environments like Geometer's Sketchpad, Cabri, Cinderella and GeoGebra, there has been a resurgence of interest in basic geometry around the world. The free availability of open-source GeoGebra (http://geogebra.org) has resulted in a burgeoning user community, primarily of math teachers. Although dynamic mathematics encourages active learning and student construction of meaning, these technologies have not been designed to support collaboration. In working with the GeoGebra software development community, the VMT Project team has

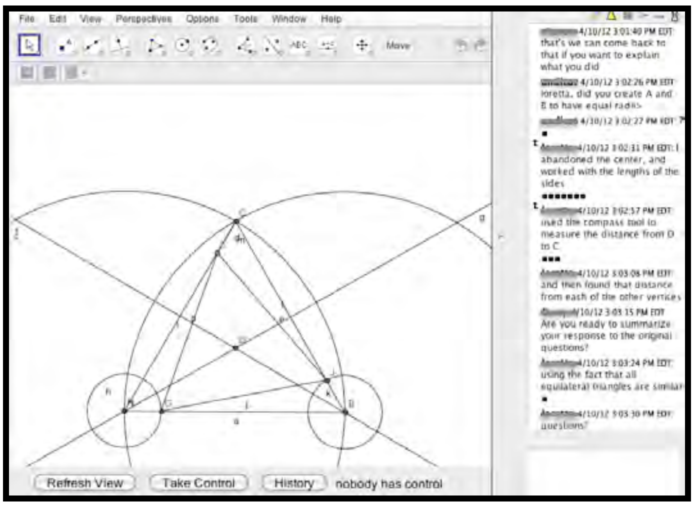

Figure 1. A view of a VMT chat room while three students are exploring a challenging geometry task.

created the first effective multi-user version of a dynamic-math environment. This allows small groups of students to collaborate on a shared construction and to engage in text chat about it at the same time (see Figure 1). This opens up the exciting new mathematical tool of dynamic math for the first time to true, convenient, supported collaborative learning. All the collaborative activity in this environment is persistent and readily available for review and reflection both during the collaboration session and at any time thereafter.

The VMT CSCL technology is unusual in that it is neither a general-purpose platform nor a single-application specialized tool. It provides a suite of components to support individual, small-group and classroom-wide collaborative learning, but it is oriented to school mathematics, especially basic geometry. We are exploring many aspects of how to use this technology to shift geometry education from the classical approach dating back to Euclid to a contemporary approach based on the principles of CSCL (Stahl, 2013b).

Another uncommon aspect is the level of pedagogical support developed within the VMT research project. This is an outgrowth of the fact that VMT has been developed at the Math Forum (http://mathforum.org), one of the first and most prominent online sites/organizations for supporting the learning of mathematics. The Math Forum has considerable expertise and experience in professional development and mentoring of math teachers. Consequently, the VMT Project provides masters-level courses and mentoring for teachers interested in introducing computer-supported collaborative learning of dynamic mathematics in their schools (http://vmt.mathforum.org/vmt/courses.html). We have also developed a hundred-page curriculum with tutorials for the use of VMT with GeoGebra in online small groups of students (Stahl, 2012).

Finally, the VMT software system includes tools for analysis of the interaction that took place within a VMT mathematics chat session. This supports reflection by students on their own group's interaction and collaborative learning, as well as reflection on that of other groups. It enables teachers to review the work of student groups at whatever level of detail they require. Also, it gives researchers access to all group interaction that took place, in a variety of convenient electronic formats. A researcher can review in complete detail everything that the students themselves experienced of the group interaction—either in a view identical to that of the students (see Figure 2) or in logs formatted for inclusion in papers. The analytic issues for research introduced by video capture and speech transcription are thereby avoided.

Case studies of interactions in the VMT environment have shed considerable light on the nature of collaborative learning in this kind of CSCL environment. They have guided the design, on-going re-design, debugging and tweaking of the VMT software, pedagogy, curricular materials, analytic tools and theory. Case studies of VMT interactions appeared in the latest issues of *ijCSCL* (Zemel & Koschmann, 2013) and *JLS* (Medina & Suthers, 2013). Other studies will be reported in a workshop, two papers and a poster at the CSCL 2013 conference (Magee, Mascaro & Stahl, 2013; Stahl, 2013a; Stahl et al., 2013; Stahl & Öner, 2013).

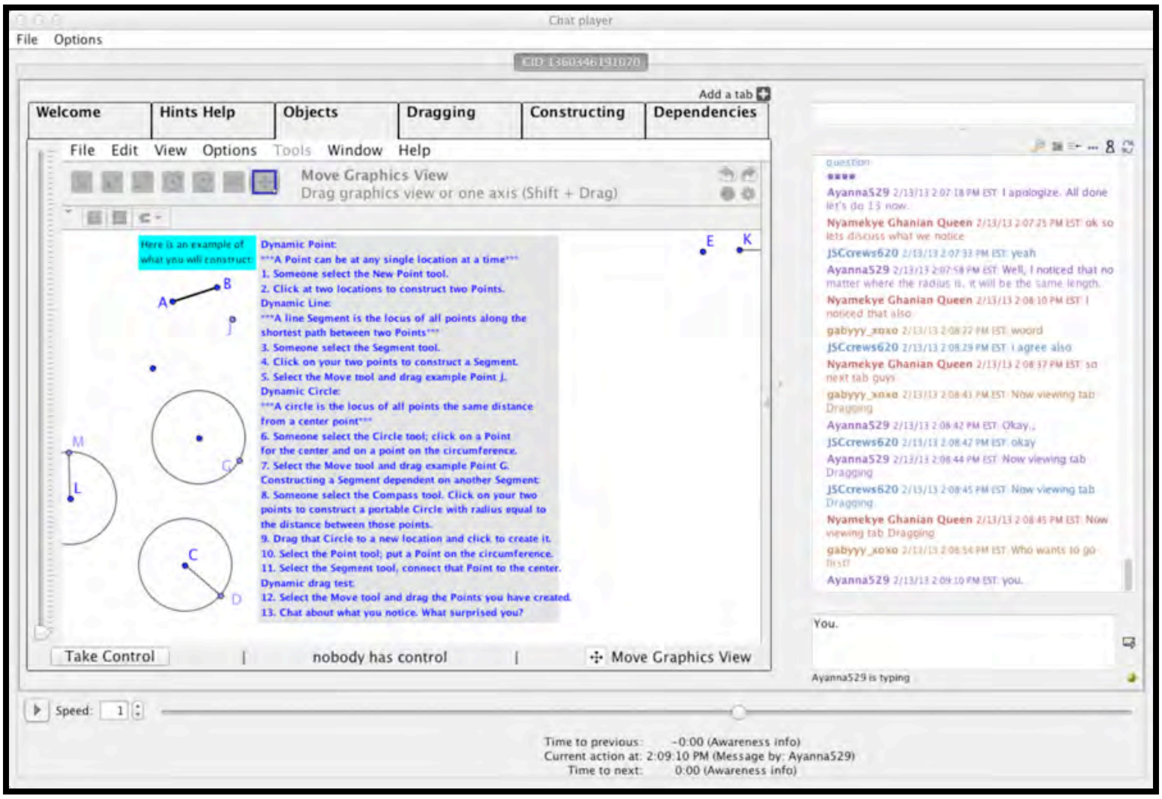

Figure 2. The VMT Replayer. Middle school students explore the elements of dynamic geometry.

Virtual Math Teams: Software, Curriculum, Pedagogy, Analysis

These are the aspects of the VMT Project support for collaborative dynamic mathematics to be presented in this demo: software, curriculum, pedagogy and analysis. The amount of time spent on each aspect will be determined based on audience prior knowledge and interests.

VMT software environment. The VMT environment is multi-faceted. There is a lobby that users enter upon login (http://vmt.mathforum.org). There they can browse a list of existing chat rooms under different math topics. Teachers can also create new rooms, review student work in existing rooms or register a class of students for VMT access. A chat room can have multiple tabs with different media; the demo will focus on the affordances of GeoGebra tabs. In particular, it will discuss the features that had to be adapted or supplemented in GeoGebra to make it truly and effectively multi-user.

VMT curriculum for dynamic geometry. A hundred-page booklet featuring 18 hour-long activities was developed for small groups of students using VMT with GeoGebra to learn basic geometry and to develop facility with GeoGebra. This includes paced tours of the software and activities for individual exploration followed by collaborative construction. Each activity includes prompts for significant mathematical discourse. The curriculum is developmental, designed to gradually increase the ability of the students to engage in open-ended exploration, reflection and un-scaffolded use of GeoGebra. The emphasis is on understanding the role of dependency in dynamic geometry through construction—to counteract a tendency in GeoGebra pedagogy toward pre-constructed apps that students or teachers simply drag around.

VMT pedagogy for teacher professional development and student collaboration. A course for in-service math teachers will be described briefly (http://vmt.mathforum.org/vmt/courses.html). This is an online CSCL-style course given at the Schools of Education at Drexel University and Rutgers University, with support from the Math Forum. It emphasizes collaborative learning through a focus on mathematical discourse, accountable talk, making thinking visible, and articulating noticing/wondering.

VMT analysis tools. Any user—whether student, teacher or researcher—can download chat logs (optionally including GeoGebra actions, etc.) in a variety of spreadsheet formats. They can also download data files for the VMT Replayer. These facilitate rigorous interaction analysis (e.g., by researchers), as well as less formal review for reflection (e.g., by students) or assessment (e.g., by teachers).

Virtual Math Teams: Demonstration

There will be a live demo (see Figure 3) of the VMT environment, with several members of the audience collaborating on simple tasks in a shared GeoGebra workspace on their own laptops.

The presenters will first give a tour of the VMT software, including the Lobby, chat room, teacher interface, social networking components, log generation, associated wiki pages and Replayer tool. Copies of curricular materials and publications will be available. Many publications on VMT and CSCL are available at: http://GerryStahl.net/pub. The analytic tools and case-study approach of VMT research will be discussed.

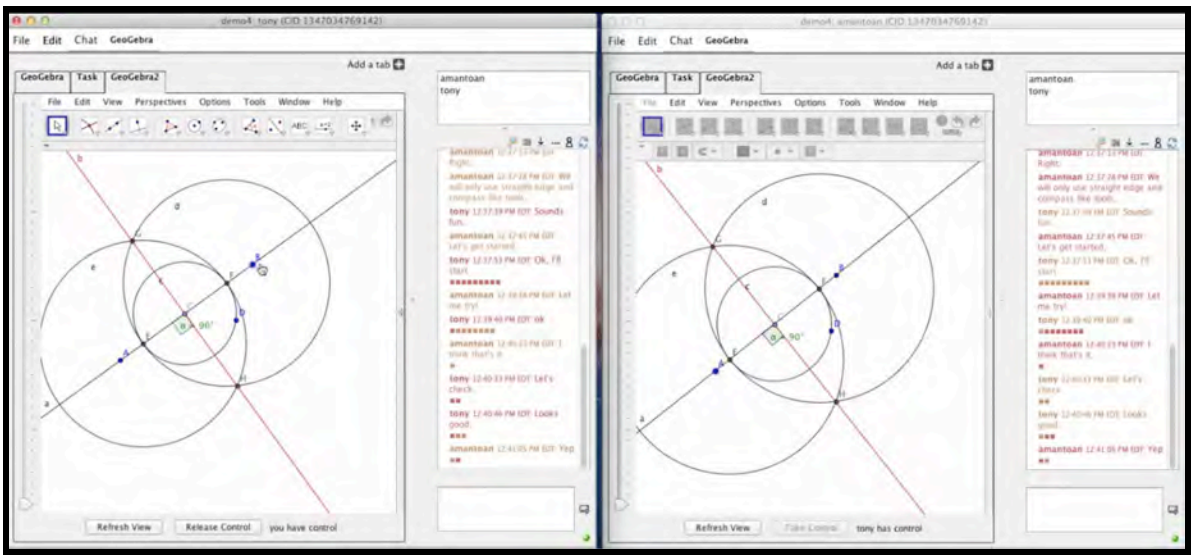

Figure 3. A demo of two students constructing, dragging and chatting about a shared geometric figure. The student on the right currently has control for using the GeoGebra tools. The other student also sees any changes made by the first student.

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- 2007-09, "Exploring Adaptive Support for Virtual Math Teams." DRL0723580.
- 2009-13, "Dynamic Support for Virtual Math Teams." DRL-0835383.
- 2009-12, "Theories and Models of Group Cognition." ONR CKI.
- 2011-16, "Computer-Supported Math Discourse Among Teachers and Students." DRL-1118773.

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Zemel, A., & Koschmann, T. (2013). Online math problem solving as a process of discovery in CSCL. *International Journal of Computer-Supported Collaborative Learning. 8*(1). Web: http://ijcscl.org/?go=contents&article=177#article17.

Towards Teaching Analytics: Repertory Grids for Formative Assessment (RGFA)

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Abstract: In this paper, we present a short description of RGFA, a web-based software implementation of the Repertory Grid method. RGFA facilitates the study of the personal constructs of students for spatial diagnosis of their knowledge levels. Repertory Grid is a method for eliciting personal constructs of learners about elements belonging to the topic of study. Repertory Grid and RGFA are a pedagogical method and a computational tool respectively of the NEXT-TELL EU project (www.next-tell-eu) that is concerned with technology enhanced formative assessment and pedagogical decision-making. System description, use cases, and an illustrative screenshot of RGFA are presented. The paper concludes with an outline of future work on the research and development of RGFA.

Introduction

Repertory Grid Technique (hereafter RGT) is a method for eliciting personal constructs of individuals about elements belonging to the topic of study. RGT is based on the seminal contribution of the Personal Construct Theory of the psychologist George Kelly (Kelly, 1963, 1992) and subsequent theoretical and methodological developments (cf. Adams-Webber, 2006; Fransella, Bell, & Bannister, 2003). RGT has been used by both researchers and practitioners in a wide variety of fields including psychotherapy (Winter, 2003), marketing (Frost & Braine, 1967), education (Bell & Harriaugstein, 1990; Mazhindu, 1992), and information systems (Cho & Wright, 2010; Tan & Hunter, 2002).

RGT consists of a family of methods and variations involving the nature of the personal construct elicitation and the rating or ranking of elements in monadic, dyadic or triadic configurations (Fransella, et al., 2003). For the purposes of formative assessment, we have decided to start researching RGT with an implementation of the widely adopted method of triadic sorting of elements for personal construct elicitation and subsequent five-point Likert-item rating of the rest of the elements (Fransella, et al., 2003).

Repertory Grids for Formative Assessment (RGFA)

RGFA (http://cssl.cbs.dk/software/) is designed and developed to achieve three interdependent research and development objectives for the use of repertory grid technique for technology enhanced formative assessment.

1. Integration of Repertory Grid into the curriculum as an in-class learning activity or a take-home exercise.
2. Methodological support for teachers to designing and deploying RGT exercises.
3. Computational support for visualizing the Repertory Grid data at the individual student and whole classroom level for formative assessment purposes for teachers and self- and collaborative learning purposes for students.

System Description

With RGFA, teachers can design Repertory Grid Exercise with a combination of elements ranging from text, pictures, and videos. The teacher specifies the elements and then configures one or more triads (combinations of three elements). Once the exercise is saved, the teacher can email the link to it to the class or share the exercise link through the course portal. When the students begin the Repertory Grid Exercise, they are presented with the triads (the sets of three elements specified by the teacher). For a given set of three elements (e.g, Windows, OSX, Linux), the student is prompted to select the element (e.g., Linux) that is different from the other two (Windows, OSX) and to state how it is different as the “opposite construct” (e.g., “command line interface”). Then, the student has to state how the two remaining elements in the triad are similar to each other as the “similarity construct”. The rest of the elements (other operating systems, in our example) are then rated on a Likert-item scale ranging from the Opposite Construct (1) to the Similarity Construct (5). The students repeat this process until all the triads of elements are sorted into different and similar and the elements for that comparison are rated. The outcome of this exercise is the Repertory Grid Table (RGT) consisting of rows with triads, columns consisting of elements with the first column being the Opposite Construct and the last column being the Similarity Construct, and the cell values consisting of the ratings given for elements. The current implementation of the teaching analytics support for RGFA displays time taken for construct elicitation and element rating phases for each triad and colors the cells with the shortest time taken in green and the longest time taken in red. Based on the RGT, the teacher can qualitatively appraise learners' "mental models"—what they see as 'going together', and on what dimensions—and/or apply clustering methods or dimension reduction methods to derive quantitative measures of learners' knowledge structures. The color coded time on task (construct elicitation) and element rating can be used to diagnose problematic triads and "conceptual gaps". Figure 1 shows a repertory grid exercise designed by a teacher. Figure 2 presents a screenshot of a completed repertory grid exercise by a student. Figure 3 shows the teaching analytics support.

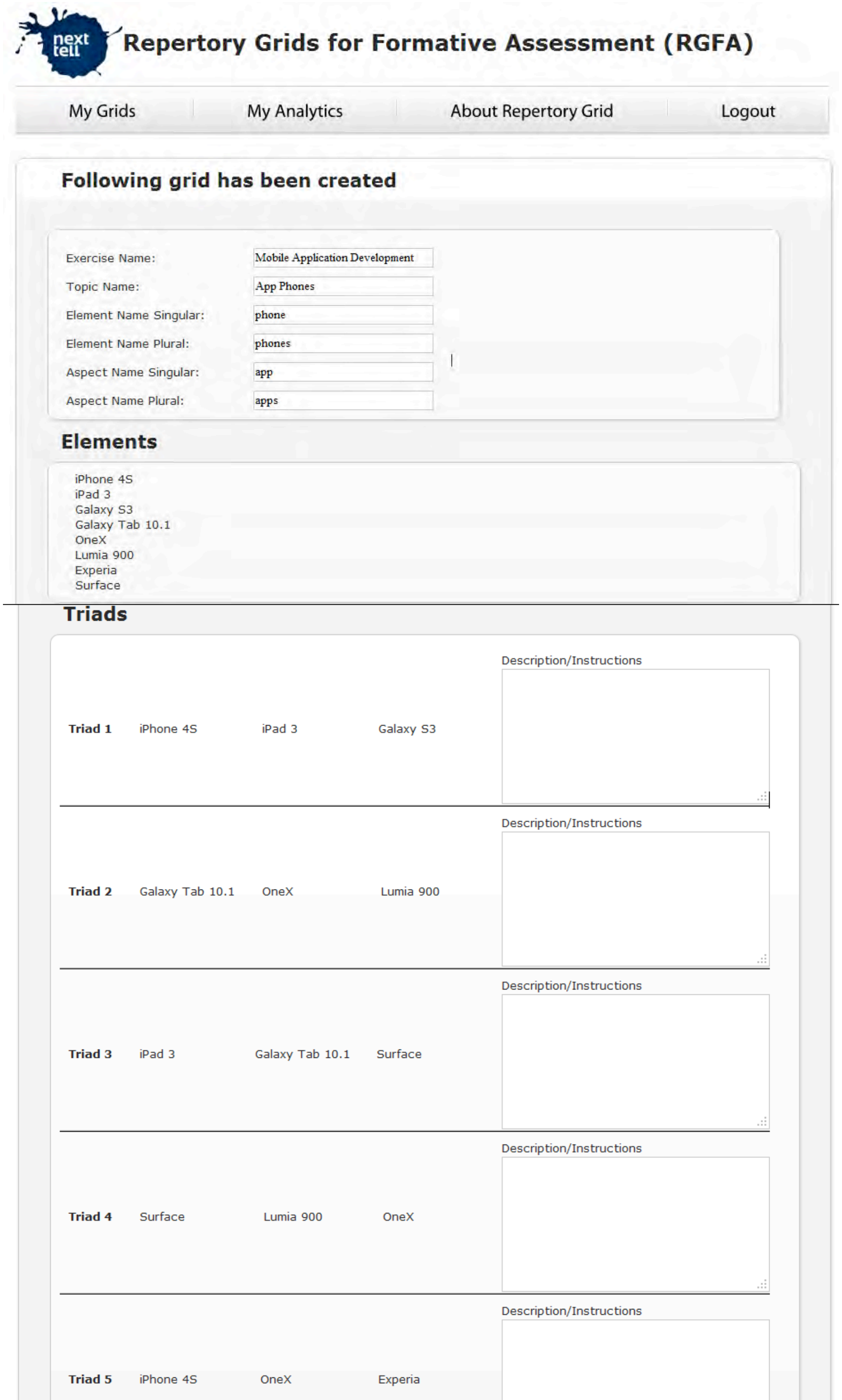
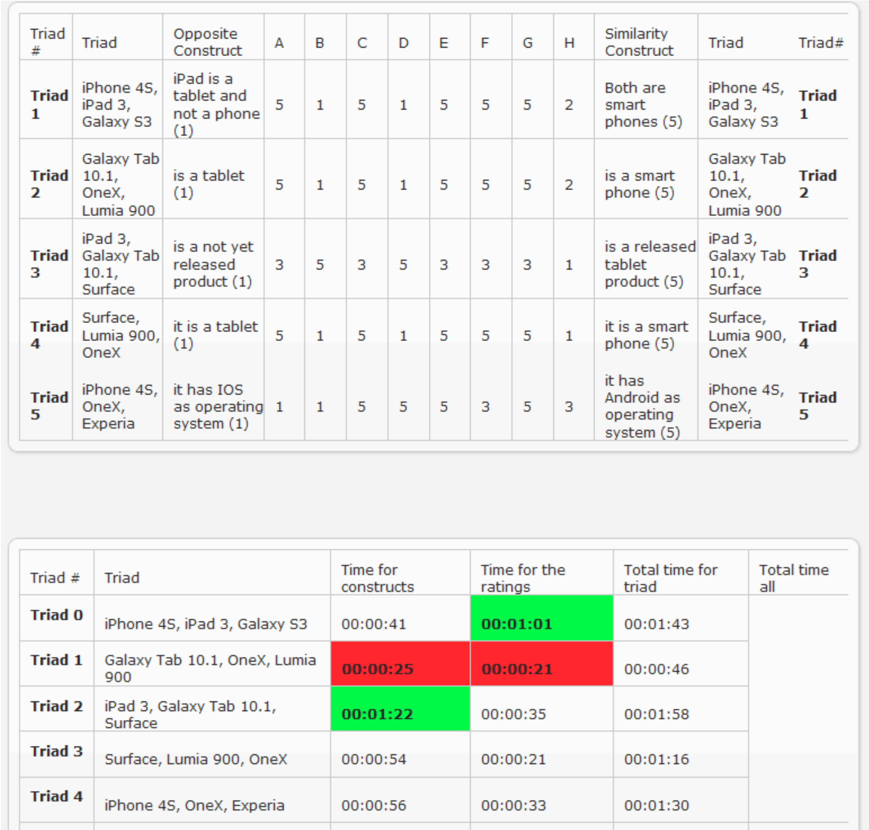


Figure 1. Example of a Repertory Grid Exercise



Triad #	Triad	Opposite Construct	A	B	C	D	E	F	G	H	Similarity Construct	Triad	Triad#
Triad 1	iPhone 4S, iPad 3, Galaxy S3	iPad is a tablet and not a phone (1)	5	1	5	1	5	5	5	2	Both are smart phones (5)	iPhone 4S, iPad 3, Galaxy S3	**Triad 1**
Triad 2	Galaxy Tab 10.1, OneX, Lumia 900	is a tablet (1)	5	1	5	1	5	5	5	2	is a smart phone (5)	Galaxy Tab 10.1, OneX, Lumia 900	**Triad 2**
Triad 3	iPad 3, Galaxy Tab 10.1, Surface	is a not yet released product (1)	3	5	3	5	3	3	3	1	is a released tablet product (5)	iPad 3, Galaxy Tab 10.1, Surface	**Triad 3**
Triad 4	Surface, Lumia 900, OneX	it is a tablet (1)	5	1	5	1	5	5	5	1	it is a smart phone (5)	Surface, Lumia 900, OneX	**Triad 4**
Triad 5	iPhone 4S, OneX, Experia	it has IOS as operating system (1)	1	1	5	5	5	3	5	3	it has Android as operating system (5)	iPhone 4S, OneX, Experia	**Triad 5**

Triad #	Triad	Time for constructs	Time for the ratings	Total time for triad	Total time all
Triad 0	iPhone 4S, iPad 3, Galaxy S3	00:00:41	**00:01:01**	00:01:43	
Triad 1	Galaxy Tab 10.1, OneX, Lumia 900	**00:00:25**	**00:00:21**	00:00:46	
Triad 2	iPad 3, Galaxy Tab 10.1, Surface	**00:01:22**	00:00:35	00:01:58	
Triad 3	Surface, Lumia 900, OneX	00:00:54	00:00:21	00:01:16	
Triad 4	iPhone 4S, OneX, Experia	00:00:56	00:00:33	00:01:30	

Figure 2. Repertory Grid Completed by a Student (Green coloured Cell indicates longest time taken and red coloured cell indicates shortest time taken)

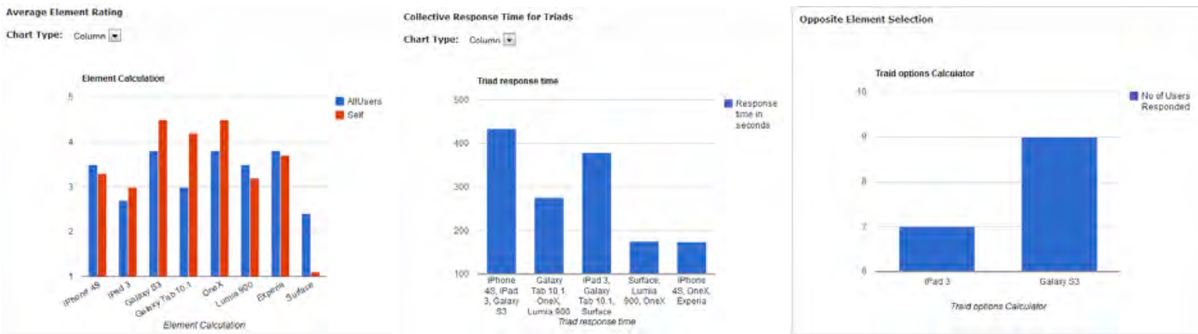


Figure 3. Teaching Analytics Support (Self vs. Class Comparison; Collective Response Time for the Class; and Opposite Element Selection Frequency Indicator)

Suggestions for Teachers

In designing repertory grid exercises, teachers should pay particular attention to the previous domain knowledge of students and to what extent the elicited constructs are grounded in the personal lived experience of the students compared to the domain knowledge. An ideal repertory grid exercise would involve 6-10 elements and 5-6 triads with each element appearing at least once and in different positions of the triad when a particular element features more than once across the different triads. The repertory grid exercise could be designed for individual students or as a computer supported collaborative learning (CSSL) exercise involving a small group of students. The pre-test and post-test paradigm could be applied to solicit individual or group repertory grids before and after a particular curriculum module has been taught. Further, the teacher can make his or her own repertory grid to the students for reflection and repertory grids of domain experts for benchmarking and guided inquiry. Post repertory grid exercise tasks could include asking the individual students or groups to reflect on their own repertory grids, inspects the repertory grids of their peers or domain experts, and/or inspect the visualizations of the repertory grids for the entire class. An additional implication from the classroom exercises and the eye-tracking laboratory studies is that teachers could also learn about students' current understanding based on the time take for construct elicitation and element rating (Vatrapu, Reimann, & Hussain, 2012).

With regard to formative assessment, teachers can inspect the constructs or the Word Cloud representations of the individual or collective constructs and discern students' level of domain knowledge. Similarly, teachers can scrutinize the elements ratings to discern students' ability to distinguish between the different concepts. With necessary training, teachers can make use of Treemap or some other visualization of the entire repertory grid exercise to adapt the content and didactics for that particular curriculum module.

Apart from the classroom usage scenario, another usage scenario for teachers is to employ the repertory grid exercise as lightweight appraisal method for informal learning tasks. We will research this usage scenario in future work with teachers participating in the NEXT-TELL project and demonstrate it at CSCL 2013.

Suggestions for Students

Repertory grid exercises on topics not inherently familiar to students either from prior formal learning settings or from personal experience seem to be perceived as challenging and engaging. That said, a well-designed repertory grid exercise on the familiar and lived practice would allow students to externalize their implicitly held constructs. Students should then be motivated and guided to reflect on their intuitions and connect their personal constructs to domain concepts.

Students should also be able to co-design repertory grid exercises with peers and teachers. Co-designing a repertory grid exercise would require students to select the topic, the elements, and the number, content and order of triads. This in itself could be pedagogically effective.

Finally, students should be given the option of sharing their repertory grids with their classmates and within their social networks. Students should be able to interact with their visualizations of their individual repertory grids and those of their peers and the classroom level repertory grid. Moreover, students should be able to upload their repertory grid exercises to their e-portfolios and integrate them with their open learner models.

Future Work

- Implement support for text analytics of the elicited personal constructs
- Implement support for detection of Zones of Proximal Development
- Implement support for collective analysis of Repertory Grid Tables
- Provide support for Principal Component Analysis and Multi-Dimensional Scaling

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Appendix: Demonstration Plan

Demo Set-up

We plan to bring two large 24" monitors, two laptops, a power strip, 2-3 iPads, and 2-3 Windows 8 tablets, and set up our own WiFi network with mobile broadband. The first laptop and monitor will show a presentation of RGFA together with a short video tutorial on a continuous loop. The second monitor and laptop will serve as the primary demonstration machine. Parallel demo sessions will be set up on the iPads and the Windows 8 tablets.

Interaction plan

Repertory Grid Technique is a method for eliciting personal constructs of individuals about elements belonging to the topic of study. Within the NEXT-TELL project, for the purposes of formative assessment, we have decided to start researching RGT with an implementation of the widely adopted method of triadic sorting of elements for personal construct elicitation and subsequent five-point scale rating of the rest of the elements(Fransella, et al., 2003). Briefly put, the triadic sorting method consists of the participants being presented sets of three elements each. For a given set of three elements, the participant is prompted to select the element that is different from the other two and to state how it is different as the "opposite construct". Then, the participant is to state how the two remaining elements in the triad are similar to each other as the "similarity construct". The rest of the elements are then rated on a Likert-item scale ranging from the Opposite Construct (1) to the Similarity Construct (5). The participants repeat this process until all the triads of elements are sorted into different and similar and the elements for that comparison are rated. The outcome of this exercise is the Repertory Grid (RG) consisting of rows consisting of triads, columns consisting of elements with the first column being the Opposite Construct and the last column being the Similarity Construct, and the cell values consisting of the ratings given for elements.

We seek to demo two usage scenarios for RGFA. First, the intended use of RGFA as a spatial diagnostic tool of students' knowledge levels. Second, we would like to demo potential uses of RGFA for inquiring into personal conception of HCI constructs such as usability assessment methods and user experience methods, requirements gathering, and as a participatory design tool.

We expect to have a localized version of RGFA supporting English, Danish, Norwegian, and German available by the time of the NordiCHI 2012 conference. In general, the following workflow for creating a RGFA exercise will be demonstrated as well as the completion of a RGFA exercise.

1. Visit
    a. Danish: http://cssl.cbs.dk/software/rgfa/Login.aspx?Countrycode=DK
    b. English: http://cssl.cbs.dk/software/rgfa/Login.aspx?Countrycode=GB

User Instructions

The instructions below are for the English version but the steps are identical to the Danish version.

2. Select Teacher" from the drop down box. (Figure 1)
3. Use "demo" as the userid and "nextell" as the password (Figure 2)
4. Click on "Create new Repertory Grid Exercise" link on My Grids page (Figure 3)
5. Enter the names for exercise, topic, element and aspects (singular & plural) (Figure 4)
6. Enter number and names of element (Figures 5)
7. Enter the number of Triads and specify the Triads (Figure 6)
8. View the completed Grid (Figure 7)
9. Click on My Grids and select Copy+Paste the link under "CompleteGrid Link" column

9. Send the following instructions to the students:
- Click on the link below:
    - o <Copy+Paste the link under CompleteGrid Link>
- Select "Student" from the drop down list and the do the new student signup.
- Follow the on-screen instructions to complete the exercise (Figures 8 & 9)

10. Under "My Grids" Select the Exercise under "Completed Grids" and click on "View" to see students' grids.

Volume 2

Pre-Conference Workshops

Designing for Distributed Regulatory Processes in CSCL

Abstract: Regulatory processes are powerful mediators of learning. Historically, processes such as self-regulated learning (SRL) have been portrayed as individual, cognitive-constructive activity focused on solo enterprise. Recent work in this field, however, has begun to tackle the impact of viewing collaborative activity, which is prevalent in CSCL, through the lens of regulatory processes. Such studies have identified types of social interactions that can be characterized under new terminology – e.g., socially shared regulation, team-regulation. Reframing SRL as social, and moving it away from a singular focus on the self to the self with others, foregrounds many substantive questions. In particular, it raises conceptual and methodological issues including how can regulation be distinguished from knowledge construction and other team processes, and how do we study the individual and the collective. This workshop will bring together SRL and interactional approaches to begin a serious discussion of challenges involved in studying social aspects of regulation.

Organizers' names and backgrounds:

Elizabeth S. Charles is a full-time research faculty at Dawson College, Montreal, Quebec, Canada. Her research interests include technology-enhanced learning environments, interactional processes and development of collective phenomena in collaborative learning. Dr. Charles worked with the Learning by Design project, as a post-doctoral fellow, and Virtual Math Teams, as a visiting researcher, where she investigated the development of collective responsibility and agency. The latter leading to a book chapter "Student and Team Agency in VMT," co-authored with Wes Shumar (2009). These experiences along with her current research project *Using Collective Conceptual Networks for Learning*, has provided opportunities to study distributed processes among the collaborative groups. Dr. Charles will co-chair the workshop. Contact: echarles@dawsoncollege.qc.ca

Mariel Miller is a doctoral candidate in Educational Psychology and senior research assistant the Technology Integration and Evaluation (TIE) research lab at the University of Victoria, BC, Canada. Her SSHRC funded doctoral research explores shared regulation in computer supported collaborative learning with a particular emphasis on (a) the social construction of task perceptions in collaborative tasks, and (b) web-based scripting and visualization tools supporting socially shared regulation. Mariel Miller will co-chair the workshop. Contact: fgage@uvic.ca

Roger Azevedo is a Tier 1 Canada Research Chair in Metacognition and Advanced Learning Technologies, and a Professor in the Department of Educational and Counselling Psychology at McGill University. His main research area includes examining the role of cognitive, metacognitive, affective, and motivational self-regulatory processes during learning with computer-based learning environments. He is the director of the Laboratory for the Study of Metacognition and Advanced Learning Technologies (http://smartlaboratory.ca/). He has published over 200 peer-reviewed papers, chapters, and referred conference proceedings in the areas of educational, learning, and cognitive sciences. A major focus of his research has been the development of MetaTutor, a metacognitve tool for enhancing self regulated learning. He is interested in the further development of multi-agent learning systems and how they can be used to co-regulate learning. He is the editor of *Metacognition and Learning*, along with editorial positions on other journals. Contact: roger.azevedo@mcgill.ca

Allyson F. Hadwin is an Associate Professor in Educational Psychology and co-director of the Technology Integration and Evaluation (TIE) research lab at the University of Victoria, BC, Canada. Her research focuses on exploring the dynamic and social nature of regulated learning as it evolves over time and through interaction with others, as well as the ways technologies can support self, co-, and shared-regulation. Research conducted by Dr. Hadwin and colleagues has been foundational in expanding self-regulated learning theory (Winne & Hadwin, 1998) and has been instrumental in developing tools for researching and analyzing SRL processes (e.g. gStudy and nStudy - web-based tools developed to assist students in SRL). Contact: hadwin@uvic.ca

Susanne Lajoie is a Tier 1 Canada Research Chair in Advanced Technologies for Learning in Authentic Settings (ATLAS), and a Professor in the Department of Educational and Counselling Psychology at McGill University. She uses a cognitive approach to identify learning trajectories that help novice learners become more skilled in specific domains of study. Dr. Lajoie's research success is grounded on the underlying cognitive and affective theories that lead to better learning and she uses such theories to guide the design of computer based learning environments. Her research is strongly interdisciplinary, using theories of cognitive science, educational psychology, and computer science (i.e., artificial intelligence). Recently, she and her graduate students have begun to look at the affordances of technology to scaffold and support joint problem solving and co-regulation through visual representation. Contact: susanne.lajoie@mcgill.ca

Workshop theme

Regulatory processes have been shown to be powerful mediators of learning (e.g., Pintrich, 2004). Until recently most studies on the topic have fallen under the heading of self-regulated learning (SRL) and focused on the individual's ability to plan, control, monitor and reflect on their cognition, motivation/affect, performance and context (e.g., Pintrich, 2000, 2004). However, there is a growing ubiquity of collaborative learning both online, in classrooms, and workplace. In part this change can be attributed to technological advances and affordances of web-based tools (e.g., video conferencing, chat and shared whiteboards) and other technologies (e.g., multi-agent systems). Additionally, in part, it can be attributed to the recent willingness of educational policy makers and institutional leaders to adopt changes based on social constructivist theories. This includes greater use of web-based tools to network learners while in classrooms (e.g., Knowledge Forum, the Innovative Technology for Collaborative Learning (OTCLE) project). In addition, the construction of new learning environments that promote collaborative work (e.g., Technology Enhanced Active Learning (TEAL) project at MIT).

Such changes have begun to drive the need to reframe and re-conceptualize regulatory processes as social and between humans, and humans and other non-human entities (e.g., artificial agents). How individuals regulate and monitor themselves and others as they work together towards a commonly shared goal has been referred to as co-regulation (Lajoie & Lu, 2012), socially shared regulation (Hadwin, Jarvela & Miller, 2011), team-regulation (Saab, 2012), externally-regulated (Johnson, Azevedo, & D'Mello, 2011), and distributed responsibility (Charles & Kolodner, in progress). Reframing regulatory processes from the self to the self with others foregrounds many substantive questions. In particular, it raises conceptual and methodological issues – how do we study the individual and the collective? – as well as philosophical issues – what models of learning best represent the shift to social regulatory processes?

Goals of the workshop

The goal of this workshop is to invite a serious discussion between experts in the field of self-regulated learning and the CSCL community. In particular, we aim to explore how interactional methods might begin to help us understand the impact of distributed regulatory processes as they mediate learning in collaborative activity. Major topics to be covered include conceptual, theoretical, methodological issues, implications for theories of learning regulation and group learning, as well as a discussion of tools need to be designed to support shared and co-regulation. Specific issues to be discussed in break out sessions are as follows: (a) how are regulatory processes distinct from group processes, (b) how are regulatory processes distinct from knowledge construction, and (b) how analytical techniques may differ in investigating co-regulation, self-regulation, social shared regulation, and team regulation.

We open this workshop to all members of CSCL. In particular, we welcome those who are interested in learning more about the role of regulatory processes in promoting successful collaboration and the role and use of designed technological supports. We will ask participants to share data samples to facilitate exploration of examples of distributed regulations from a variety of contexts.

Theoretical background

Self-regulated learning (SRL) refers to the strategic control of thoughts, actions, motivations, and emotions to achieve personal goals and adaptively respond to environmental demands (Zimmerman, 1989). From this perspective, regulated learning involves (a) intentionally negotiating task goals and standards to guide work, (b) strategically adopting and thoughtfully adapting tools and strategies to optimize task performance and learning, (c) monitoring progress and intervening if results deviate from plans, and (d) persisting and adapting in the face of challenges (Winne & Hadwin, 1998; Zimmerman, 1989).

Historically, models portrayed self-regulated learning (SRL) as an individual, cognitive-constructive activity (e.g., Winne, 1997; Zimmerman, 1989) focusing on individual regulatory processes and outcomes in solo tasks. However, considering regulation in CSCL means extending focus to explore how students regulate themselves as well as others as they work together and influence one another in a joint task in a situated context. Whether one views regulation from a socio-cognitive perspective as influenced by environmental context, from a socio-cultural perspective as appropriated through participation, or as situated in social activity systems, to understand regulation, one needs to know something about social context and/or interplay (Schunk & Zimmerman, 1997; Volet, Summers, & Thurman, 2009).

As such, in the emergent research, various forms of regulation of learning have been posited to occur during CSCL at different levels. One recent framework for regulation in computer-supported collaborative learning suggests achieving success in CSCL depends upon: (a) the self-regulatory skills and strategies individuals bring to the group, (b) transitional support provided to one another to facilitate self-regulatory competence within the group, and (c) shared or collective regulation of learning such as metacommunicative awareness, shared motivation regulation and successful coordination of strategies (Hadwin, Jarvela, & Miller, 2011). In this case, regulation of learning in collaboration can occur within the individual, among group members, and within the group itself.

Methods

In this workshop we will feature both exemplars of distributed regulation from different contexts relevant to CSCL as provided by the workshop organizers (see three cases below). Additionally, we will solicit a small number of case studies from participants. These case studies and their data will form the foundation of the workshop and the discussions around the themes of methodological and theoretical challenges. We will use both socio-cognitive and socio-cultural lenses to inform the methodological approaches we explore to examine how regulation can be distinguished from knowledge construction and other team processes. In particular, we welcome approaches that explore interactions between the individual and the collective levels.

Case 1: Using scripting and visualization tools to support computer-supported collaborative problem-solving (CSCL)

Self-regulated learning, co-regulated learning, and shared regulated learning are posited to play a central role in productive collaboration (Hadwin, et al, 2011; Jarvela & Hadwin, in press). Computer-supported collaborative learning (CSCL) research suggests groups consistently struggle to collectively regulate, especially in terms of constructing shared metacognitive knowledge including perceptions of task requirements and purpose (Miller & Hadwin, 2012; Hurme et al., 2009). This study examined the effectiveness of scripting and visualization tools in a CSCL collaborative task for supporting shared regulation of task perceptions. Participants included 150 undergraduate students working in groups of 3 to 5. Six groups were compared across two conditions in which they were provided with (a) a script prompting group analysis of task requirements and purpose or (b) a script augmented with a mirroring tool visualizing individual members' task perceptions. Data included individual and group statements of task interpretations, text-based chat discussions, activity log files, and statements of challenges identified by each group member. Focusing specifically on the negotiation of task perceptions, we compared the challenges encountered by groups, the processes used to construct “shared” task perceptions, and the quality of task perceptions across the two conditions.

Case 2: Examining the nature of co-regulation in a computer-supported problem based learning environment

This study explores the nature of co-regulation in an on-line synchronous problem based learning (PBL) environment of medical students and tutors from Canada and Hong Kong (Lajoie, et al., 2012). The instructional goal of the environment is to help medical students learn how to communicate bad news to patients. We created a CSCL learning environment using Adobe Connect, where we connected these medical students and tutors in a problem based learning environment. The synchronous CSCL tools include video based exemplars used to trigger the learning experience, video conferencing, chat, and shared whiteboards to support collaborative engagement. In particular, we explore the social aspect of metacognition (Salonen, Vauras & Efklides, 2005) and examine how private cognitions are influenced by social experiences (Hacker & Bol, 2004)

Case 3: Co-regulated learning between human and multiple artificial pedagogical agents during learning with MetaTutor

Current research on multi-agent learning systems has focused on self-regulated learning (SRL) while relatively little effort has been made to use co-regulated learning as a guiding theoretical framework. For example, learning with a multi-agent hypermedia learning environment such as MetaTutor involves having a learner interact with four artificial pedagogical agents (see Azevedo et al., 2012, in press). Each agent plays different roles including modeling, prompting, and scaffolding SRL processes (e.g., planning, monitoring, and strategy use) and providing feedback regarding the appropriateness and accuracy of learners’ use of SRL processes. In this study we focus on four main issues: (1) learner-initiated and learner-agent regulatory processes that foster students’ internationalization of regulatory processes and learning about challenging domains; (2) the emerging interaction patterns of learner and agent regulatory behaviors, including the mediation and internalization of SRL processes; (3) whether distributing regulatory expertise amongst multiple agents is effective in enhancing learners’ internalization of SRL; and, (4) if there are emerging interactions of learner-agent that are predictive of learners’ internalization of SRL processes? Analysis of data from this study reveals the following co-regulatory processes: (1) the nature of learner-initiated and agent-initiated regulatory moves, (2) the impact of agents’ co-regulation on learners’ instructional choices, and students’ adoption of different regulatory processes.

Relevance to field and conference

Education and training programs have increasingly implemented collaborative work in Computer Supported Collaborative Learning (CSCL) environments to afford learners opportunities to enhance essential teamwork skills and learning. Two decades of research evidence success of CSCL in supporting shared knowledge construction and productive interactions as well as individual and collective outcomes (Salomon, Perkins & Globerson, 1991; Roschelle & Teasley, 1995). However, CSCL technologies often generate over-expectations. Simply providing groups with opportunities to collaborate does not automatically result in success and knowledge co-construction cannot be achieved merely by supporting functional, social and cognitive team work processes; (Dillenbourg, Järvelä, & Fischer, 2009). Collaboration is a challenging endeavor. It requires groups to grapple with ill-structured tasks while coordinating engagement across multiple individuals with unique perspectives and interpretations (Barron, 2003; Erkens, Jaspers, Prangsma, & Kanselaar, 2005; Hadwin, Järvelä, Miller, 2011; Järvelä & Hadwin, in press; Roschelle & Teasley, 1995). Groups encounter a wide array of social and cognitive challenges derailing their efforts, and many groups fail to reach their full potential (Kreijns, Kirschner, & Jochems, 2003; Phielix, Prins, Kirschner, Erkens, & Jaspers, 2011).

As such, increased emphasis has been placed on how in team members individually and collectively regulate their learning in CSCL contexts (Hadwin, et al., 2011; Hadwin & Järvelä, in press; Saab, 2012). Regulated learning can be considered to be the quintessential skill in collaborative learning. Without it, collaborative work may become de-railed or less satisfying for learners resulting in less effective, efficient and/or enjoyable learning. From this perspective, investigating regulation of learning needs to consider such things as the ways: (a) knowledge of tasks, strategies, goals and group are regulated during collaborative work, (b) knowledge of self, collective and each other's beliefs, feelings and motivations are regulated, and (c) behaviors and actions with a group are regulated to influence collaborative outcomes. Furthermore, successfully collaborating in CSCL contexts requires targeted support for promoting or guiding not only individual self-regulatory skills and strategies, but also peer support and facilitation of self-regulatory competence within the group as well as shared or collective regulation of learning.

Expected outcomes and contributions

While collaboration and teamwork are increasingly required across academic and work contexts, examining regulation in CSCL is fruitful line of research that can create new opportunities to understand and maximize the success of 21st century learners. However, while social or shared regulation is theorized to be an important mechanism in effective collaborative learning, research in this area is in its infancy. This workshop aims to contribute to knowledge and understanding in this area by (a) taking steps toward much needed conceptual clarity of how regulation unfolds in collaboration, (b) bringing together varied perspectives about how regulation unfolds in CSCL, (c) contributing to development of new measures and analytical techniques extending beyond the traditional focus on individual outcomes and processes to capture how groups dynamically regulate across the individual and group level, and (d) informing ways in which learners and groups can be supported in regulation in CSCL environments.

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Educational Game Design - Prototyping with purpose

Abstract: Pro-social video games, or games that use video game design to address a social issue, are inherently interdisciplinary, oftentimes requiring content experts and designers work together. Given recent successes (e.g., *Fold-it*) and the increased interest that governments, non-profits groups, and academics, have shown in researching and developing new pro-social games, practices that can accelerate and improve the interdisciplinary collaboration should be explored. *Game jams*, or time-constrained goal-oriented design events, are regularly used in commercial development and design education and may be similarly useful in pro-social development contexts given their focus on innovation and collaboration.

Organizers

Matt Gaydos is a dissertator at the University of Wisconsin, Madison who, with colleagues, has organized dozens of game design jams, including two Global Game Jams sites and three game jam workshops for the Games Learning Society Conference.

Kurt Squire is the co-director of the Center for Games Learning and Society, a professor in the school of Education, and vice president of the Learning Games Network. He oversees the creative direction of the educational games made by the center.

Dennis Ramirez is a doctoral student in Curriculum and Instruction at the University of Wisconsin-Madison and lead developer at the Center for Games Learning and Society.

Ryan Martinez is a doctoral student in Curriculum and Instruction at the University of Wisconsin-Madison whose research focuses on how games facilitate reflections on society. He also works as a game design and assessment consultant.

Clem Samson-Samuel is a graduate student at the University of Wisconsin, Madison researching ways to design games that teach cultural competency. Clem is a game designer with more than 12 years experience, including eight years with the triple-A studio, Raven Software.

Theme & Goals

The theme of this tutorial is hosting and designing game design workshops that can be used to support innovation. In particular, the tutorial introduces participants to game jam and goal-oriented design practices used throughout the game industry. Practices used from innovate independent game development studios to highly successful commercial development houses. The goals of this event are to educate participants on how to conduct game design sessions at their home institutions, to discuss and anticipate roadblocks that may arise (e.g., share "best practices"), and to examine different outcomes of these design sessions that may be beneficial for research and development both locally and globally.

Theoretical Background and relevance to field and conference

Research has begun to invent new pro-social ways to play games, drawing on variety of domains and theoretical perspectives. For example, scientific discovery games like *Fold It* have improved scientists' understanding of protein folding by leveraging the resources of large player communities to overcome computational limitations (Cooper et al., 2010). Commercial action video games like *Call of Duty,* have been studied as useful tools for improving visual attention training (Dye, Green, & Bavelier, 2009). In education research, video games and their player communities are being explored as models from which to design new learning environments (e.g., Clark, Nelson, D'Angelo, & Menekse, 2009; Gee, 2003). Researchers across multiple disciplines and from different approaches have begun to explore ways that video games may not only entertain their players, but positively impact the world as well. In order to support the continued improvement of pro-social game development – namely with regards to the quality of the games and the breadth of issues addressed – it may be useful to explore methods that accelerate the rate and quality of interdisciplinary work. Game design sessions are one such method.

Inventing new games for research purposes poses significant challenges. New pro-social games often require that game developers integrate particular and often expert-level content into a game's design. For some games, this means leveraging already-existing genres and adapting known mechanics or tropes in order to instantiate content. The educational game *Virulent,* for example, includes strategic elements of *Starcraft,* a popular commercial real-time strategy game with complex strategy, interface elements of *Harbor Master*, a commercial game released on mobile iOS devices, and contemporary virology research conducted by Paul Ahlquist. Some research games, like *Fold-it,* have fewer prior design models from which to work, however, and must cover more ground in order to invent new player experiences while at the same time covering complex expert material. Pro-social video game development is inherently cross-disciplinary in nature, and must meet the challenge of creating a well-designed game (that is also ideally entertaining) while at the same time having a positive impact on the world.

Game jams and goal-oriented design sessions maybe useful in meditating some of the challenges associated with pro-social game development. These kinds of sessions challenge participants to create a playable game that adheres to a particular theme within a limited amount of time. Often ranging from an hour to a week, game design sessions and other similarly constrained design events are a low-cost, prototype-focused practice that is growing in popularity amongst commercial developers (Rose, 2013). Especially for students and independent studios, game jams have already been used to push the boundaries of the medium (e.g., the *Independent Game Jam*), and to introduce design students to the process of production (e.g., the Global Game Jam). When leveraged for pro-social purposes, design sessions may be a useful method for prompting collaborative work between designers and content experts and for pushing the field forward in terms of design innovation.

Relevance

Game design sessions align with two current research areas that are important to the CSCL community. First, because these sessions embrace practices of good design that may be useful for their participants as education interventions. For example, good design often means accommodating the inherently messy process of moving between an artifact and its use in context through methods like rapid prototyping and iteration (Hoadley, 2002). Design sessions can be useful in introducing participants to this process, given their focus on quickly designing and developing a working game with a team of other developers. Digital video games design has also been used to introduce students to tangentially related content or skills, such as programming and scripting (Overmars, 2004; Kafai, 2006) and digital literacy or design thinking (Games; Gaskin, 2011). In these contexts, students are asked to learn the medium of expression (e.g., code) while learning how to clearly express themselves (e.g., design). Non-digital game sessions offer participants the opportunity to avoid technical challenges and instead practice translating their designs into games while still benefiting from the process of collaborative learning (e.g., sharing goals, understanding, and information). A good deal of research has already been conducted wherein students design games for educational benefits (c.f. Kafai, 2006) and design session provide a contemporary, lightweight, industry-practiced tool that may be useful in extending currently existing educational interventions and research projects. When using non-digital media (paper, pencils), for example, design sessions can be especially useful for students and content experts who lack programming backgrounds but are nevertheless invested in solving a particular design challenge.

The second area of research that design sessions may benefit is in the development of new games that are themselves, advancements in the field. Games for scientific discovery, games that instantiate new models of learning, and games that introduce sophisticated content have begun to redefine collaborative learning. *Fold It* community members for example, have produced tools to help new users solve more advanced puzzles, blurring the boundaries between content that is valued within the game community and content that is valued within the scientific community. Successes like *Fold it* are rare, however, and cross-discipline development that leverages game development and content expertise may be accelerated by design sessions where content experts and game designers actually sit down to design a game together. Game design sessions provide a practical method for accomplishing this sort of collaboration, as they require few resources, little time, and little to no technical background of participants.

Expected Outcomes and Contributions

Participants will get first-hand experience participating in a design session developing their own game under time and thematic constraints. In doing, participants will learn the basic format for running a session. Through discussion, participants will learn and share various conditions under which sessions might be run, and discuss any anticipated problems that may arise. Participants will also discuss and propose their own goal-oriented design sessions, including for the use of design curriculum and field innovation. Contributions to the field include the spreading of a commercial development practices that may be useful at participants' home institutions as a research, development, and collaboration tool. A collective blog will be proposed for participants to document the games that they make.

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Computer-Supported Collaborative Learning at Work: CSCL@Work -- Bridging Learning and Work

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Abstract: We created an interdisciplinary workshop to explore principles of computer-supported collaborative learning in work settings. The workshop's theme was, simply CSCL at work. Our first workshop at ACM Group 2010, the 2nd at ACM Group 2012, and the resulting book, raise an important set of issues and potentials for research, but does not solve the thorny and controversial issues. This workshop wanted to make progress on the identified issues. The CSCL@Work workshop was a half-day workshop devoted to **sharing innovative approaches and discussing solutions aimed at understanding, studying and designing 'learning at work' supported by digital/mobile technologies**. We selected the CSCL conference as an ideal venue for a workshop on this topic because the North American and European communities who participate in the Learning Sciences include leading members of the international CSCL communities. The workshops at ACM group focused more on CSCW whereas this proposed workshop on CSCL2013 included CSCL researchers. It started with contextualizing the current situation. Then, participant questions and proposed solutions aimed at the issues we have raised and begun to recognize. We focused on working groups, an approach, which supports knowledge building. To participate in the workshop, discussants was asked for a position paper of up to 2 pages in standard CSCL conference format. Our edited book was made available to participants in advance, and selected authors provided overviews of their work and perspective in an interleaved way with the more action oriented working sessions.

Organizers' background

The three organizers represent research in different areas bridging CSCL and CSCW communities, as well as North American and European communities (Their websites: http://www.groupinformatics.org/sean.p.goggins https://iml.edusci.umu.se/ictml/team/isa-jahnke/ and http://www.imtm-iaw.rub.de/)

Theme

Most CSCL-research is dedicated towards learning in educational institutions such as schools or universities – and therefore neglects the workplace as the main opportunity for informal lifelong learning. Intertwining collaborative work and collaborative learning has a huge potential for research as well as for practitioners. Our experience is that this is especially relevant for organizations adopting new and disruptive innovations. In 2010, we conducted a first workshop on the topic CSCL@Work. Our subsequent publication of a book framing the topic area, CSCL@Work (Goggins, Jahnke & Wulf, in press) demonstrates a growing understanding of the relationship between supporting collaborative learning in the workplace, organizational adaptation to a changing environment and regional economic growth. The proposed workshop on CSCL@Work will explore key design principles and research questions associated with computer supported collaborative learning in work settings. As John Seely Brown notes in the foreword to our book especially informal learning achieves increasing relevance:

> "In a world of constant change where many of our skills have a half-life measured in a few years and many of our institutions are experiencing creative destruction at a daunting pace, we need to find ways to merge the best insights from formal education, where the goal is to learn what is already known, with those of organizational and workplace learning, where at least one of the main goals is to create new knowledge" (John Seely Brown, 2012).

To build a bridge between learning *what is known* and learning *that creates new knowledge* is of crucial importance for both the computer supported collaborative learning community and the computer supported collaborative work community (dePaula & Fischer, 2005). Such a "culture of participation" (Fischer 2011) is also needed for researchers, consultants and designers of CSCL@Work to foster learning@work concepts.

CSCL typically focuses on learning as a primary activity. By contrast, CSCL@Work also considers the fact that learning means to provide employees with timely access to information for conducting everyday work while primarily respecting business goals; learning in these cases is a secondary activity and work is the primary activity (Mørch & Skaanes, 2010), while both together aim at performance improvement.

We distinguish CSCL@Work from prior research of CSCL, CSCW and knowledge management. Prior work is focused on computer supported collaborative learning, much of it investigating the application of computer support for learning in the context of traditional educational institutions, like public schools, private schools, colleges and tutoring organizations. Inspiring new theories of how knowledge is constructed by groups (Stahl, 2006), how groups and individual reflect their work experiences (Knipfer, Kump, Wessel & Cress, in press, how teachers contribute to collaborative learning and the application of socio-technical scripts is emerging from workplace studies [Bodker & Christiansen, 2006; Crabtree et al., 2006, Turner et al. 2006].

Theoretical approaches (relevance to field and conference)

A number of existing works provide empirical research on collaborative work practices [Davenport, 2005; Lave & Wenger, 1991], the sharing of information at work [Brown & Duguid, 2000], and the development of communities of practice in workplace settings [Wenger, 1998]. Others examine the munificent variation of information and communication technology use in the work place, including studies of informal social networks, formal information distribution and other socio-technical combinations found in work settings [Hinds & Weisband, 2003].

Empirical research on cooperative work practices (Lave & Wenger, 1991; Davenport, 2005), the sharing of information at work (Brown & Duguid, 2000), and the development of communities of practice in workplace settings (Wenger, 1998) show how knowledge can be shared in communities of practice when that knowledge is known inside of an organizational context. But problems related to the distribution of knowledge holders and their knowledge remains unsolved (dePaula & Fischer, 2005). Prior, well-known findings like these rely on the premise that knowledge within an organization's walls can be actively diffused across the organization (Gibson & Cohen, 2003); then proceed to describe various models explaining how that occurs. Those knowledge management approaches are premised on a certain degree of environmental stability inside a company. The notion, that you can "store knowledge", implies it is likely to be useful for some period of time sufficient to justify the effort of capturing it.

The workshop aims to fill a void between existing discourses in CSCW, knowledge management and CSCL, and will open with a short presentation by an expert (e.g., Gerhard Fischer) characterizing the emerging application of collaborative learning theories and practices to workplace learning. CSCL and CSCW research each make distinct and important contributions to the construction of collaborative workplace learning, first identified by Billet (2002). From the workshop in 2010 and 2012 at ACM Group, we could collect first design principles, such as (a) Making Technology-embraced learning at the workplace visible, (b) Enabling learning at work across established traditional workplace boundaries; such as using private devices (e.g. smart phones) for learning; fluid transition between learning at the workplace and everyday learning, (c) fostering collaborative reflection that incorporate feedback and different learning loops from diverse sources of Social Media.

Guiding questions and **topics** for knowledge building at the workshop on CSCL2013 were:

- Theories, pedagogies and models for CSCL@Work to enhancing creative skills for knowledge-building and problem-solving - What are the theoretical and methodological implications of the (empirical) cases presented, and where do they take this emerging research space?
- Identifying strategies for gaining access to workplace learning research sites.
- Key design principles for CSCL@Work - How can tools and methods of the recent CSCL-research be transformed to be applicable for CSCL@work?
- What is the nature of learning in a CSCL@Work setting and is this different from learning in schools?
- Didactical designs for CSCL@Work enhanced by mobile devices
- Learning design approaches to enhancing CSCL@Work including design patterns

- Development methodologies for CSCL@Work
- Innovative mobile applications/tools for fostering CSCL@Work incl. virtual learning environments & gaming
- Informal work-integrated learning, vocational education and vocational learning; workplace training
- Innovative mobile user interfaces for creativity including concepts and products towards CSCL@Work
- User stories, case studies and evaluations of CSCL@Work
- Future visions for CSCL@Work including frameworks and methodologies
- Socio-technical solutions and process design for collaborative learning at the workplace

We invited different types of contributions ranging from work in progress, demonstrations and results from research and practice, academia and businesses. Authors submitted original unpublished research as extended abstracts (max. 3 pages). It included a description of the theoretical concept, and a definition of CSCL@Work, learning and the computer support (e.g., Social Media, mobile devices), underlying presented work and empirical research results (if it was available). Since the approach is interdisciplinary, the workshop did seek to attract different participants, including students, research in companies, designers, practitioners and developers. Papers reviewed and selected by the Program Committee were published on the website www.csclatwork.org

Goals

Three goals motivated the proposal for this workshop:

a) To identify and discuss key design principles (social, technical, sociotechnical, didactical/pedagogical design) of CSCL@Work, presented by the organizers and discussants.
b) To identify theoretical and methodological commonalities and contrasts across the represented disciplines relative to CSCL@Work. This includes helping CSCL researchers identify organizations where workplace learning can be studied, and introducing themselves to stakeholders in these settings.
c) To focus the community around CSCL@Work on the challenge of integrating their efforts directly with business and industrial organizations who need new tools and techniques to survive in an economy where basic paradigms of operation are undermining their previously stable enterprises.

Expected outcomes and contributions

We expected that the participants of the workshop have not already done original research in the field of CSCL@Work but are interested to exploit the potential of their recent research for this field. In preparing the workshop we did analyze the submissions for deriving typical patterns for CSCL@work to use them as framing or scaffold knowledge building during the workshop. We started with very short presentations and went on with breakout groups, which gathered around posters being prepared by the participants. The material like slides, discussions and outcomes of the small groups interactions are available online: www.csclatwork.org. There, the reader also find new created research questions, the new developed agenda for doing research in CSCL@Work and next steps on the way to create a social network towards CSCL@Work-

Workshop format (half day)

The aim of this workshop was to share current research and practice and to initiate a joint design of CSCL@Work applications and scenarios in order to inform theories and methodologies. The workshop was composed of the *morning inspiration event* during which innovative ideas to fostering CSCL@Work was presented in the Pecha Kucha format to ignite creative thinking and inspire the collaborative development during the late morning session. The Pecha Kucha event is based on a simple idea: each presenter presents 20 slides - 20 seconds each (approx. 6' 40" in total). It is a creative presentation format that enhances sharing of multiple ideas and gives more presenters the chance to share their research.

During the *second session*, the discussion of a CSCL@Work framework was supported by workshop organizers utilizing a mix of different creativity techniques. The inputs from the Pecha Kutcha session were used to inspire work in small groups aiming at designing CSCL@Work. Group work will include brainstorming and storyboarding as creativity techniques, which will be supported by mobile media, i.e. (a) MindMeister for collaborative, mobile mind mapping, and (b) WhiteBoard-App for documenting collaborative story boarding on online white boards. Participants of the workshop brought their laptops and smart phones to participate in the interactive workshop activities (4 hrs in total including breaks).

The organization of the workshop is summarized in the table below:

Time	Topics	Methods	Tools
08:30-08:45 (15 mins)	Welcome and introduction of the workshop and participants	Symbols for activating brainstorm associations	Postcards
8:45-09:45 (60 mins.)	**Pecha Kutcha Event**	Pecha Kucha presentations and spring-boarding	Panopto for Pecha Kutcha live streaming and recording, Socrative for ideas generation
15 mins	*Coffee break*		
10:00-11:30 (90 mins.)	**Power Mind Mapping and Story Boarding**	Mind mapping in small groups	MindMeister app, White board Apps for digital documentation
11:30-12:15 (45 mins.)	**Group Presentations**	Short presentations	Bambuser (live streaming & recording)
12:15-12:30 (15 mins)	Summary and outlook	Weather forecast	

Participants
We started to identify potential participants who have **committed** themselves to take part in the workshop before the workshop has been conducted: Beside the three organizers Sean Goggins (USA), Isa Jahnke (Sweden) and Thomas Herrmann (Germany), the committed participants were: Anders Morch (Norway), Leif Hokstad (Norway); Hilda Tellioglu (Austria); Michael Prilla (Germany), Heide Lukosch (Netherlands), Ulrike Cress (Germany). These persons have been included in outlining the workshop proposal and helped to recruit further participants. Furthermore, and through a call for position papers, we did recruit further participants (read "Dissemination activities").

Dissemination activities
The workshop was conducted under the patronage of the CSCL at work group, which brings together international researchers in learning and work-integrated learning. The dissemination activities did exploit a range of social media for the viral spread of information, including Twitter, personal blogs and social media networks, such as the CSCLatwork Facebook group and the website www.csclatwork.org, and were accompanied by the use of the unified hash tag for #csclatwork. These activities were important to attract high quality submissions from various communities and to build an International network of stakeholders interested in bridging learning and work by digital technologies, Social media and mobile devices. Resources from the workshop, including accepted abstracts, Pecha Kutcha presentations (and high likely recordings of live streams), are available on the website www.csclatwork.org in order to spur further discussion in the community and spin off creative CSCL@Work initiatives.

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Michael Prilla, University of Bochum, Germany
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From Data Sharing to Data Mining: A Collaborative Project to Create Cyber-Infrastructure to Support and Improve Design Based Research in the Learning Sciences.

Abstract: The goal of this workshop is to organize and synthesize the ideas of a team of researchers from a variety of fields into a web-based infrastructure to support design-based research (DBR). This work is supported by an NSF grant. This will be the first opportunity for selected team members to collaborate on a system design that will be developed and beta-tested in the following stages of the grant project. We anticipate that an initial design will emerge that includes methods and/or tools to address several challenges of DBR; to document and share prospective learning designs, to capture and document design changes during implementation, and to present multi-level visualizations that allow large datasets to be exhibited, shared, traversed, and explored at different grain sizes and levels of detail. Researchers with an interest in DBR working in such areas as information visualization, data mining, machine learning, and learning analytics will be invited.

Organizers

Alan J. Hackbarth, is an assistant professor of Psychology, University of Wisconsin-Colleges. He is a co-author of an NSF grant that supports the research related to the proposed workshop.

Sharon J. Derry is a professor of learning sciences, UW-Madison. She is a co-author of an NSF grant that supports the research related to the prosed workshop.

Sadhana Puntambekar is a professor of learning sciences, UW–Madison. She is collaborating on this project and brings expertise in design-based research, especially examining the different grain sizes and levels of analysis in design research

Theme and Goals

The organizers of this workshop have been awarded an NSF grant to assemble a select team of researchers to collaborate on the design and beta testing of a web-based infrastructure to support design-based research (DBR) in the Learning Sciences. We anticipate this project will synthesize current work in DBR methodology with work in areas such as information visualization, machine learning, learning analytics, and online data mining. A goal of this project is to encourage and support engagement by multiple researchers in working toward answers to important theory-driven research questions for DBR, moving our field toward a "bigger science" research approach. Our strategy is to bring researchers together to invent a system for supporting DBR that would be sufficiently structured and standardized to facilitate data sharing and collaboration, sufficiently flexible to allow researcher-users to employ a variety of analytical approaches, and sufficiently robust to support DBR research in many types of settings.

Data analytic tools have emerged in a number of fields – learning analytics tools that focus on student performance to improve teaching and learning (Baepler & Murdoch, 2010), financial analysis tools, and analytical tools that have predicted election results from sampled polling data with uncanny accuracy (Retrieved from http://mashable.com/2012/11/07/nate-silver-wins/, November 20, 2012). Virtual experimentation on standardized shared datasets is now routine in the physical sciences. We in the Learning Sciences have an unprecedented opportunity to co-opt these and our own tools into a system that increases our understanding of learning.

Theoretical Background

In this section we will review the challenges of DBR that will be addressed by the conceptual system that emerges and evolves from workshop presentations and discussions and then briefly review descriptions, theoretical principles and research in the fields of information visualization, machine learning-based analysis, learning analytics and data mining. We will conclude the section by summarizing the relationships of these fields to one another and the rationale for including researchers from these fields in the workshop.

Design Research

Design-based research is grounded in the systematic design and study of instructional strategies and tools in authentic contexts (Barab and Squire, 2004); as such, there is no one accepted definition or methodology. The Design-Based Research Group (2003, p. 5) identifies characteristics of "good" design-based research. The critical characteristic is that the central goals of designing learning environments and developing theories or "proto-theories" of learning are intertwined. Development and research takes place through continuous cycles of design, enactment, analysis, and redesign, and research must account for how designs function in authentic settings – not only in terms of success or failure, but also on interactions that refine understanding of the learning issues involved.

Collins, Joseph, and Bielaczyc (2004) describe challenges that a design-research team faces when implementing design experiments. Foremost is that research is usually conducted in the "blooming, buzzing confusion" of classroom learning environments (Brown, 1992). There are many variables that influence the success of a design, and many of those variables cannot be controlled (Collins, Joseph, & Bielaczyc, 2004, p. 19) – e.g., availability of resources at a particular time. Furthermore, each variable is part of a systemic whole; it is impossible to change one aspect of the system without creating perturbations in others (Brown, 1992). It is important to identify the critical variables of a design and how they fit and work together in practice (Collins, Joseph, & Bielaczyc, 2004, p. 34). One needs a well-developed profile of an implementation in order to analyze a design in terms of its key elements and their interactions; some elements will be implemented more or less as the designers intended, some will be changed to fit the circumstances, and some will not be implemented at all. However, because of the number a variables to account for, design researchers usually end up collecting large amounts of data, more data than they have time or resources to analyze (Brown, 1992; Collins, Joseph, & Bielaczyc, 2004, p. 19). This can make analyses difficult and results less certain. A system (i.e., methodology and tools) that organizes and documents data in an easily accessible format is essential for facilitating more efficient and effective analyses.

Chris Hoadley (2004) writes about the difficulties of achieving *rigor* when conducting DBR in a complex classroom environment. He notes that researchers cannot control for learners' prior experience (a significant covariate), cannot ensure that the "treatment" is identical across situations, and that a double-blind study methodology has limited use in educational settings. In addition he suggests as fundamental the problem of "context": the difficulty in educational research of assuming universality; the difficulty of experimental control when there are literally dozens of interacting factors; understanding that "treatments" might not go as planned; and understanding that the enacted intervention is a *dependent*, not and independent variable – the intervention ***is*** the outcome. Hoadley suggests that the notion of how to do DBR raises many questions related to achieving rigor:

- How can we ensure that we have adequately characterized an interaction we did not entirely control?
- How can we document interactions and outcomes when these outcomes are not known in advance?
- Will the results obtained in one context generalize to another, and other what conditions?
- How can we characterize the second- and third-order affects of a designed intervention as it is enacted in a particular context and the implications for not only the learning but the context itself?
- Will others be able to implement similar interventions in their local contexts in ways that are similar enough to include the benefits of any "successful" intervention?

These and other questions will guide the selection of workshop presentations and orient and drive the discussions of a web-based visualization system that supports DBR.

Information Visualization

The widely accepted definition of information visualization is "*the use of computer-supported, interactive, visual representations of abstract data in order to amplify cognition*" (Card, 2008). Visualizations harness the perceptual capabilities of the human visual system and allow a viewer to; (a) examine a large amount of data, (b) keep an overview of the whole while pursuing details, (c) keep track of many things by using the display as an external working memory, and (d) produce an abstract representation of a situation through the omission and recoding of information. (Card, 2008). Computers increase the cognitive capability of the human visual system because they allow for interactive, multi-dimensional graphic representations that organize and thereby reduce the search for information. This enhances the detection of patterns, enables perceptual inference operations, and supports efficient computational processes by distributing them between brain and computer (Spence, 2001).

A key problem for information visualization designers involves identifying *visual metaphors* for representing information and understanding the analysis tasks they support (Gershon & Page, 2001). Designers of visualizations tend to capitalize on metaphors that can give users a sense of intuitiveness and/or familiarity. From a user's point of view such a visualization is either easy to understand or easy to learn through interaction. Shneiderman (cited in Chen, 2010) summarizes the essential elements of interacting with graphically presented information: overview first; zoom and filter; and then details on demand. The all important function of an overview is to depict interrelationships among units of information. Information space metaphors are popular because they invite navigational operations such as zoom, pan, or rotate that allow users to understand information intuitively or understand it quickly through interactions with the visualization. In addition, a graphic design that has visual structures at several scales can aid in the search process; large scale structure provides a means for finding important mid- and small-scale information (Ware, 2008).

The ultimate design question is whether salient features of geometric or structural patterns convey the intended message to the viewer (Chen, 2010). The attachment of meaningful geometric or visual encoding is much more arbitrary when viewing a visualization of an abstract topic (i.e., analysis of a journal article) than when viewing a scientific visualization of, for example, a thunderstorm. Research on how humans visually process the world as we solve problems has provided a great deal of insight on how to design visualizations that help viewers solve particular problems related to the information on display (Ware, 2008). Many of these insights have been incorporated into Edward Tufte's (1990, 1997) principles for enriching the density of data displays: use macro/micro readings, layer and separate information, use color, small multiples, and narratives of space and time. In turn, Tufte's principles are reflected in the work of many researchers in the Learning Sciences and need to be a primary topic of discussion in the workshop.

Machine Learning-Based Analysis

Broadly speaking machine learning is described as a scientific field addressing the question "How can we program systems to automatically learn and to improve with experience?" Mitchell (2006) says more precisely "a machine *learns* with respect to a particular task T, performance metric P, and type of experience E, if the system reliably improves its performance P at task T, following experience E." Depending on how T, P, and E are specified, the learning task might also be called data mining, autonomous discovery, database updating, or natural language processing. Machine learning is also described as "the computational study of pattern discovery and skill acquisition" in which researchers develop and employ various methods in statistical machine learning, natural language processing and information retrieval. (Retrieved from http://www.cs.umass.edu/faculty/machine-learning, November 20, 2012).

Natural Language Processing (NLP) is one example of a machine learning process that has long been used to automatically analyze textual data (Mu, Stegmann, Mayfield, Rose, & Fischer, 2012). However, text classification tools are generally designed for power and flexibility instead of simplicity which make them potentially difficult to use when working with educators in designed learning environments. Machine learning tools such as TagHelper and SIDE were developed to be educator-friendly and used to automate the content analysis of collaborative online discussions. While these publicly available automated tools have been widely downloaded and better accessibility features have been added, they are not without limitations – e.g., generated models are context sensitive and case dependent which has resulted in low transfer, and automatic segmentation without the provision of natural borders of segments has been less than satisfactory. But the realization of these limitations has led to more focused research in areas such as the integration of information extraction techniques for improving content analysis. This research, as well as work in areas such as *relational knowledge discovery* – i.e., constructing useful statistical models from data about complex relationships among people, places, things, and events – and the analysis of multimodal computer mediated human interaction data (Dyke, Lund, & Girardot, 2009) needs to be included in the discussion and development a system that organizes, documents, and facilitates efficient analysis of large amounts of data collected in DBR.

Learning Analytics

As envisioned in The Horizon Report (2012) learning analytics promises to "harness the power of advances in data mining, interpretation, and modeling to improve understandings of teaching and learning." (p.22) In its early stages of development, "learning analytics" refers to the collection, organization, representation, and interpretation of a wide range of data produced by and gathered on behalf of students in order to assess academic progress, predict future performance, and spot potential issues. Data are collected from explicit student actions, such as completing assignments and taking exams, and from tacit actions, including online social interactions, posts on discussion forums, and other activities that are not directly assessed as part of the student's educational progress.

The use of learning analytics for research on learning in higher education has centered primarily on identifying students who might be at risk of failure in a course or program, and designing interventions to help them succeed in their coursework. The Signals Project at Purdue University is an exemplary instance of this use (Arnold, 2010). Signals gathers information from course management systems and course grade books to generate a risk level for students, and those designated as at-risk are targeted for outreach.

The larger promise of learning analytics, however, is the potential to more precisely understand students' learning needs and to tailor instruction appropriately far more accurately and far sooner than is possible today. This has implications not simply for individual student performance, but in how educators and researchers perceive the processes of teaching, learning, and assessment. It is not difficult to extend this notion to research; the potential to record and "see" how students engage with and utilize various elements of a designed learning intervention will better facilitate the ability to design more effective lessons and develop and test theories about how students learn.

Data Mining

The overall goal of the data mining process is to extract information from a data set and transform it into an understandable structure for further use. Aside from the raw analysis step, it utilizes methods of machine learning and statistics and involves database and data management and visualization. The actual data mining task is the automatic or semi-automatic analysis of large quantities of data to extract interesting patterns such as groups of data records (cluster analysis), unusual records (anomaly detection) and dependencies (association rule mining). Patterns can then be seen as a kind of summary of the input data, and may be used in further analysis.

A particular kind of data mining called *comprehensive workflow mining* - "the rediscovery of an explicit control flow model given a workflow event log" (Rembert, 2006) was utilized by Hackbarth (2012) when building a prototype visualization system for organizing and exploring data generated by the implementation of theory-based lesson designs (Go to http://vmc.wceruw.org/workflow/workflow.html to see the prototypes). The Collaboration Technology Research Group (CTRG) at the University of Colorado – Boulder developed a workflow modeling language called Information Control Nets (ICN) that broadened the scope of workflow mining to include a wider range of perspectives than traditional control flow as seen in Petri Nets. The additional perspectives prompt the recovery of data such as *what* tasks or activity must occur, *when* tasks are done, *which* data is processed and the *data flow* of the process, *who* or *what* performs a task, and *how* a task gets done and resulted in a richer representation of the task workflow. A graphical component of the modeling language allows for the generation of visualizations from which pattern detection can more easily occur. This is one of many potential examples of data mining techniques or systems that may arise in workshop discussions.

Summary

There is a high degree of relatedness between the four fields of research discussed here. Data mining plays a role in machine learning and related analytical tools as well as learning analytics. Information visualization is related to learning analytics and data mining and, to some degree, machine learning-based analyses. Machine learning-based analysis is or can certainly be an integral part of learning analytics. These overlaps of techniques and grounding principles should help foster collaborative conversations amongst workshop participants and facilitate the synthesis of research from the various fields into a more comprehensive conceptual system to support DBR.

Relevance

This project is relevant to CSCL at two levels. First, as a methodology, DBR is often used by researchers in this community. As such, developing a resource for capturing and archiving data is valuable to the field. Second, the project provide an opportunity for collaboration across the various fields of research in the CSCL community, providing a common platform for discussion about DBR, a unique and evolving methodology in the learning sciences.

Expected Outcomes and Contributions

We anticipate this project will synthesize current work in DBR methodology with work in areas such as information visualization, machine learning, learning analytics, and online data mining to create a system with the following kinds of functionalities, although this is not a final or complete description:

- Document and share learning-environment designs, including inputs such as activity structures, contextual information, curricular and assessment materials, learning technologies, and the theoretical bases, hypotheses, and outcomes of design experiments.
- Provide a standardized, structured web-based resource that will scaffold researchers from all over the world in the processes of designing studies and of ethically capturing, organizing and archiving large quantities of data from disparate sources (e.g., instructional materials, assessment, video data) that may be generated when implementing multiple design iterations.
- Provide the ability to capture and document design changes that occur as adaptations made by researchers during design implementations or are the product of instructors' "on-the-fly" decisions or unforeseeable circumstances.
- Present real-time multi-level visualizations that will allow large datasets to be exhibited, shared, traversed, explored and viewed at different grain sizes and levels of detail to facilitate archiving, sharing and collaborative data analysis.
- Provide some level of automatic analysis of data and data mining to facilitate and speed the analytic process and promote the pursuit of some agreed-upon research questions of central importance to the field with data mined from across projects.

As noted earlier, the "work" being proposed for the workshop supports a larger research project funded by NSF; to assemble a select team of researchers to collaborate on the design and beta testing of a web-based infrastructure to support DBR in the Learning Sciences. We expect a significant subset of workshop participants to remain engaged in this project after the workshop and contribute to the design and development of a visualization system that facilitates a better understanding of learning.

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DUET 2013: Dual Eye Tracking in CSCL

Abstract: Dual eye-tracking (DUET) is a promising methodology to study and support collaborative work. The method consists of simultaneously recording the gaze of two collaborators working on a common task. The main themes addressed in the workshop are eye-tracking methodology (how to translate gaze measures into descriptions of joint action, how to measure and model gaze alignment between collaborators, how to include gaze in multimodal interaction models, how to address task specificity inherent to eye-tracking data), empirical studies involving dual eye tracking and more generally future applications of dual eye-tracking in CSCL. The DUET 2013 workshop is a follow-up to DUET 2011 held at ECSCW 2011 conference and DUET 2012 held at the CSCW 2012 conference and brings together scholars who currently develop the approach as well as a larger audience interested in applications of eye-tracking in collaborative situations. The workshop website is available at: http://www.dualeyetracking.org/.

Background of the organizers

Dr. Patrick Jermann is a researcher and a lecturer at the Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland. He studies the regulation of collaborative interaction and since January 2010, he works on a three-year stipend from the Swiss National Science Foundation to design and develop a computational model to automatically assess collaboration quality based on actions, audio logs and dual eye-tracking data. He supervises dual eye tracking research at the CRAFT lab (http://craft.epfl.ch). In last two years he has organized the DUET workshops at the ECSCW 2011 and CSCW 2012 conferences (http://www.dualeyetracking.org) and has served on the program committee of the Eye Gaze in Intelligent Human Machine Interaction workshop at IUI 2011.

Prof. Darren Gergle (Carnegie Mellon University, PhD) is an Assistant Professor at Northwestern University in the interdisciplinary institute, “The Center for Technology and Social Behavior.” He is the director of both the Collaborative Technology Laboratory and the Northwestern University Mobile Tracking Laboratory. Dr. Gergle’s research is in the field of Human-Computer Interaction (HCI) and focuses on applying cognitive and social psychological theories of communication to the design, development and evaluation of novel collaboration technologies. His current work involves the development of computational models of collocated interaction that can be used to develop interactive applications. Central to this work is the development of a mobile dual eye tracking system that permits eye-tracking studies to extend beyond a typical 2D plane and into real-world naturalistic settings.

Dr. Roman Bednarik conducts research in the area of human-computer and human-human computer-mediated interaction. The focus of the research is on learning, problem-solving, and educational technology. He employed and developed methods of eye-tracking methodology and gaze-based interaction in numerous studies. For example, he applied eye-tracking to measure visual attention of programmers and problem-solvers. Currently, he is the principal investigator of the three years Academy of Finland grant investigating the ways of how eye-tracking can be used to support learners in collaborative situations, by modeling and enhancing expertise transfer and engagement.

Prof. Pierre Dillenbourg is a former teacher in elementary school. He graduated in educational science (University of Mons, Belgium). He started his research on learning technologies in 1984. He obtained a PhD in computer science from the University of Lancaster (UK), in the domain of artificial intelligence applications for educational software. He has been professor assistant at TECFA, University of Geneva. He joined the Ecole Polytechnique Fédérale de Lausanne (EPFL) in November 2002. His current interests concern computer-supported collaborative learning (CSCL): the design and experimentation of interactive furniture; the effects of awareness tools on group performance and mutual modeling; the authoring of CSCL scripts; the use of eye tracking method for predicting interaction patterns. Pierre Dillenbourg has been consultant for companies in Switzerland and Europe. He is the editor of the Kluwer Series "Computer-Supported Collaborative Learning" and former president of the International Society for Learning Sciences.

Theme and goals

Dual eye-tracking (DUET) is a novel methodology to study and support collaborative work. The method consists of simultaneously recording the gaze of two collaborators working on a shared task. Dual Eye-Tracking (DUET) has been applied in collaborative situations to study basic communicative processes (e.g. grounding, referencing) as well as more complex problem solving and collaborative learning environments (e.g. program understanding, playing collaborative games).

Eye-tracking methodology appears promising to study collaboration as well as to support it. Possible applications include gaze-awareness and deictic tools, automatic scene labeling based on co-reference, group decision support, facilitating multiparty distant communication, etc. Eye-tracking is becoming more readily accessible with the recent development of low-cost video-based eye-trackers. Leading companies in the field (e.g. Tobii, SMI) develop OEM eye-tracking components that could soon be part of mass-market applications.

Figure 1. A typical dual eye-tracking experimental setup. Two eye-trackers synchronously record collaborators while they solve a problem.

The DUET workshop aims at deepening our knowledge of the role of gaze in understanding and supporting collaborative interaction and addresses the methodological challenges standing ahead of applications of (dual) eye-tracking applications in CSCL.

Empirical Studies, Tools and Applications

Referential communication

Most empirical studies using dual eye-tracking contain some aspects of referential communication. Collaborators achieve mutual understanding by grounding their conversation through backchannel signals, acknowledgments, and references. According to recent views, a reference is a composite signal that consists of an indication and a verbal description (Clark & Bangerter, 2004). In face-to-face situations and video-mediated situations, pointing is accomplished by hand and arm gestures, and the lack of visual access to the shared workspace or the imprecision of pointing is compensated by more explicit verbal references (see for instance Kraut, Fussel & Siegel, 2003; Bangerter, 2004). The balance between gesturing and speaking follows the principle of least collaborative effort (Clark & Wilkes-Gibbs, 1986), such as the participants in a conversation will combine the means they have at their disposal to minimize the cost of establishing reference, for example by using gestures rather than spoken references if they convey enough information.

Gaze and speech are coupled. Meyer, Sleiderink and Levelt (1998) reported an average difference of 700 ms between the moment speakers start looking at the object and the moment they name it. Griffin and Bock (2000) propose the notion of eye-voice span as a measure of time difference between last fixation on an object and the word onset about that object. In their experiment the eye voice span for subject and object nouns was 902 ms and 910 ms respectively. Zelinsky and Murphy (2000) have shown that there is a correlation between the time spent gazing at an object and the spoken duration for naming that object. Conversely, Allopenna, Magnuson and Tanenhaus (1998) showed that the mean delay between hearing a verbal reference and looking at the object of reference (the listeners' voice-eye span) is between 500 and 1000 ms. The combination of eye-voice and voiceeye coupling is that the gaze of speakers and listeners are coupled with a lag of about 2000 ms. Richardson, Dale and Kirkham (2005, 2007) showed that the listeners' level of understanding is correlated with part on the tightness of this coupling. The coupling of gaze and speech is especially important when speakers refer to objects. Fussell, Setlock and Paker (2003) studied the gaze of helpers in a remote collaborative physical task (robot construction); and found that the helpers look more at the target, pieces and the workers' hands than the workers face. Cherubini, Nüssli and Dillenbourg (2008) used eye tracking in a remote collaborative problem solving setup to detect the misunderstanding (distance between the referrer's and the partner's gaze points) between the collaborating (through chat) partners; and found that the pairs with high misunderstanding had large distances between the reference and the gaze. Jermann and Nüssli (2012) showed in a pair programming experiment that sharing selection in a groupware was used opportunistically to support verbal references. The selectors gaze at the selection about four to six seconds before the selection is made. The collaborators who see the selection on their screen look at the selection 600-800 ms after the selection is made. The authors also showed that the gaze cross-recurrence (a measure of gaze coupling between partners) is highest when selections accompany speech.

Collaborative referencing not only consists of a one-sided production of references. Collaborators need to make sure that their partner has perceived and understood their reference. Gaze alignment between partners appears to be strongest when collaborators refer to elements of the workspace. More studies are needed to understand basic communication and coordination processes in tightly controlled experimental tasks, and especially about the interplay of speech, gaze and deictic gestures (e.g. pointing, selecting, or in mobile situations, moving about in the scene and postural orientation) which are important for high learning outcomes.

Gaze Awareness Tools

Several studies have explored the possibility of using gaze-sensitive applications in order to enhance remote collaboration. The general rationale consists of replaying in real-time the gaze of one collaborator on the screen of the other, thus providing some clues about the partner's focus of attention. One approach consists of displaying the partner's eyes. A preliminary work in this direction is the Clearboard system by Ishii and Kobayash (1992) which allows people to work on a whiteboard-like system while the seeing the partner as if they where face-to-face. Similarly, Monk and Gale (2002) used a system composed of translucent displays and mirrors in order to reproduce the face of the collaborators on the screen of their partner in such a way that the gaze direction corresponds actually to what they are looking at. Another gaze-awareness system is the GAZE groupware from Vertegaal (1999). It allows remote meetings between several people in a virtual environment where each collaborator is represented by a picture, which rotates according to the person's gaze direction.
Another approach consists of displaying the partner's gaze. Velichkovsky (1995) used a somehow different setting, which simply reproduces the eyes fixations, collected by an eye tracking device, of one collaborator onto the screen of the other as small dots. They showed that it could help people to solve puzzles collaboratively and that it changes their way of communicating. Also, RealTourist (Qvarfordt et al. 2005) is another system, which allows a remote tourist consultant to see tourist's gaze on a shared map while helping to plan a trip. The authors explored how this information (interest detection, referent disambiguation, etc..) is used by the consultant and they showed that it may improve the quality of the collaboration. In different settings, Stein and Brennan (2004) showed that programmers are more effective to find a bug in a source code if they could see beforehand a replay of the gaze of another programmer. Another study (Brennan et al. 2008) showed that two people solving an O-in-Qs search task were much faster if they could see the gaze of their partner, which suggests that gaze could be a very good clue to coordinate parallel activity. In the domain of collaborative referencing, a gaze awareness tool could support the speaker and the listener by graphically reflecting whether they focus on the same part of the shared workspace. Gaze does not need to be used as a deictic tool since simple interface functionalities, like sharing the text selection across partners' workspaces, can efficiently support the deictic aspect of the reference (Jermann & Nüssli, 2012).

Many questions remain open about the design of gaze awareness tools. Among the factors, there are the display modalities (on demand vs. automatic), the display format (real-time vs. summarized), the way users handle errors and imprecision and how awareness tools are complemented by explicit deictic references.

Scaling up to complex tasks and settings

In naturalistic situations the challenge is to understand how short-lived gaze patterns relate to longer cognitive and communicative processes (Jermann, Mullins, Nüssli & Dillenbourg, 2011). For example, is it possible to identify gaze characteristics that are specific to certain levels of reasoning (e.g. about concrete of abstract aspects of the task, about cognitive or metacognitive aspects), levels of expertise, roles in the interaction, or certain communicative actions (e.g. prompting, telling)?

In a collaboration modeling approach the collaborator's gaze could be used by a system to assess the quality of communication, the level of understanding, quality of grounding. Open questions concern whether it is possible to identify "signatures" of (in-)efficient interaction, how gaze complements other sources of data (audio, interface actions).

Methodological challenges

The study of the collaborative aspects of attention as well as the design of gaze-sensitive groupware requires a series of methodological issues to be solved.

Temporal granularity: moving from fixations to joint action

The temporal resolution of eye-tracking data is very high compared to traditional behavioral measures used in studies of collaboration (e.g. interface actions, utterances). In addition, the raw data recorded by the eye-trackers needs post-calibration and extensive filtering to be representative of attention. What can low-level gaze and fixations tell us about higher cognitive activities? How and to what level of time scale does gaze data need to be aggregated to reliably reflect collaborative learning outcome? What existing methods for behavioral modeling can be reused with gaze data?

Multi-modality: combining gaze with other behavioral signals.

The (intelligent) computerized support of interaction regulation has been investigated since the late 90' and still is of actuality (see for example Soller, Monès, Jermann and Muehlenbrock, 2005). To summarize, two broad approaches have been taken to measure features of the interaction, event based and dialog based modelling. The analysis of low-level behavioral signal sources like gaze and audio (but also gestures, biological signals) brings forth new challenges. Multi modal modelling techniques for interaction analysis are widely used in automatic meeting analysis (e.g. McCowan et al, 2003) but have not yet been used in the CSCL field. Open questions include: how is gaze combined with other communication modalities (particularly speech) and can the multiplicity of modalities help possible to detect learning outcomes from gaze patterns?

Measuring alignment: defining convergence of attention.

Collaboration and joint attention is about gazing "together" on the same object of attention. The spatial and temporal definitions of "together" still need to be defined as statistical variables that reflect some collaborative gaze behavior. For example, it is possible to use a distance in pixels between the fixations of collaborators for the "togetherness" of gaze. However, a distance-based definition is rather arbitrary and "togetherness" depends on the threshold distance used to define "together". An alternative consists of using dynamic areas of interest and a cosine-based similarity measure that accommodates areas of interest of varying sizes (Jermann, Nüssli & Sharma, 2012). Another problem for example is how gaze clouds are converted to joint gaze / awareness and how these gaze points relate to real world objects, etc. Another problem is the sensitivity of gaze alignment measures to scrolling and zooming. The definition of a basic set of standard variables and normalization methods would facilitate the exchange and comparison of results among researchers in the field. It can also inform the eye-tracking analysis software industry about which indicators are useful when looking at collaborative data from CSCL environments.

Task specificity: generalizing results across settings.

Eye-tracking data is task specific. Gaze traces strongly depend on the visual nature of the task representation. The same back and forth pattern between two objects does not have the same meaning if it stems from a collaborative program understanding task than if it comes from building a concept map. The task specificity makes it difficult to generalize findings from one setting to another and hence, makes it difficult to compare different theoretical and methodological approaches. What are relevant task typologies that can be used to organize and compare findings from eye-tracking studies? What can be learned from task independent features (e.g. fixation duration)?

Tracking techniques

There are technical challenges to use eye-tracking with off the shelf CSCL environments (e.g. a shared text editor, a programming IDE, a collaborative spreadsheet, a chat room, a discussion forum). The definition and tracking of areas of interest for instance is not straightforward as the geometry of the CSCL environments is dependent on display devices. Areas of interest should be tailorable to refer either to small elements (tokens, words, verbs, nouns, etc.) or larger aggregates (paragraphs, pages, etc.). What impact does task specificity have on recording dual gaze (e.g. how to compute alignment in relaxed WYSIWIS situations)?

With regards to mobile eye-tracking (users are free to move in the physical world, for example sitting around a table sketching a blueprint, or manipulating a tangible simulation), the identification of the target of fixations becomes even more challenging. Regions of interest can for instance be recognized with a geometrical framework for eye tracking (Mazzei, Kaplan & Dillenbourg, 2012) which applies a feature point based method to recognize a document page and estimate its planar pose robustly. This technical step is essential in the analysis of mobile eye tracking since it is necessary to determine at all times the position of the subject who is recorded with regards to the areas of interest. A simpler option to the texture mapping method consists of using fiducial markers (Fiala, 2005) to facilitate the computation of the users' position in space (e.g. Gergle & Clark, 2011). To define areas of interest in the physical world, the objects or the edges of the areas of interest are simply marked with fiducial markers. The scene camera records the markers and allows computing precisely the relative position of the subject with regards to the objects of interest.

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Human-Computer Interaction and the Learning Sciences†

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Abstract: Human–Computer Interaction (HCI) research has been highly influential in understanding the potential of new technologies to support human activities. Research in the Learning Sciences (LS) draws on multiple fields to improve learning and education. Both are active research communities with well-established practices, core values and a substantial body of literature. As both concentrate on utilizing computing technologies to better support people, there is a natural overlap; however, the Learning Sciences are not simply HCI applied to the domain of learning. The practices, traditions, and values are substantially different leading to tensions are keenly felt by researchers who actively participate in both fields. They also make it harder for researchers in either field to move towards the other. To explore and improve the relationship between these fields, we organized the workshop "Human-Computer Interaction and the Learning Sciences." This workshop was meant for both interdisciplinary researchers (i.e., active participants in both communities) and researchers from either discipline interested in the other field. In this paper, we support these audiences by providing introductions to the two fields: their histories, values and practices.

Introduction

There has been recent interest in the Learning Sciences (LS) to build on the tools, methods, and knowledge of Human-Computer Interaction (HCI). Many of the problems of technology-supported learning and education are not primarily addressed through innovations in learning theory (a particular emphasis in LS) but by addressing problems through usable and innovative designs (an emphasis in HCI). At the same time, work in HCI that focuses on learning and education could benefit from the methods and theoretical focus of the learning sciences. There are some questions that may need an answer from the intersection between HCI and LS, for example: how to make sure that usability issues in the user interface do not affect students' learning outcomes? Which design principles should be considered when designing learning tools? Are usability tests enough to evaluate a learning application?

Much research in the field of HCI studies how people interact with computers and to what extent the computer interfaces are developed for successful interaction with humans (Myers, 1998). HCI Research has been a key factor that has driven the evolution of computing as we know it and nowadays almost all software that is written provides some type of user interface. HCI itself is interdisciplinary, resting on foundational principles of computer science, psychology, design, human factors, and ergonomics. However, HCI techniques themselves cannot fully evaluate the effectiveness of a learning user interface (Coppin, 2011). Generally, the relationship between a learner (and multiple learners) and the computer(s) involve a rich number of processes and dynamics happening in and around learners' context.

The purpose of this workshop is to establish a better sense of the relationship between HCI and LS Particularly, the workshop aims to explore if the right questions can be set and whether the intersection between HCI and LS can offer some answers towards the construction of more effective learning tools and interfaces.

The Learning Sciences

Learning sciences has its roots in the cognitive science revolution, which demonstrated that modeling the cognitive aspects of the brain was useful for understanding behavior. Based on its origin in psychology, research on cognitive science primarily built on conducting controlled laboratory experiments of simplified tasks that focused on a specific aspect of cognition. As Lave (1988) demonstrated, these artificial tasks did not adequately describe or predict cognition in the wild. So, while cognitive science research claimed implications for learning and education, it was not clear that these held validity and therefore, there was little general interest in putting the implications into practice. Thus, the Learning Sciences community split off to concretely address the problems of learning and education. It retained cognitive science's emphasis on theory and model building, and a scientific approach to conduct research.

A first emphasis of the LS is on theories of learning: *what goes on in the mind*. Techniques for encouraging learning, in both formal and informal education, should build on a sound understanding of how people learn (Bransford, Brown & Cocking, 2000). A second emphasis is on theories of instruction: *what goes on in the world*. While the former has implications for the latter, the latter cannot be solely derived from the former. Useful theories in both areas can inform practice. For instance, cognitive apprenticeship (Collins, Brown & Newman, 1989) combines a cognitive theory of learning with an apprenticeship theory of instruction; in comparison to traditional apprenticeship, the focus is on cognitive skills. Learning by Design (Kolodner et al., 2003) combines a case-based reasoning theory of learning with a problem-based learning theory of instruction. A third emphasis of the LS is on design-based research: *simultaneously improving and studying learning*. Although controlled experimental studies are still valued, additional focus is given to creating effective activities or environments. One influential technique was design experiments (Brown, 1992), which prescribed a process of iterating between controlled laboratory studies and realistic field studies.

A fourth emphasis of the LS is on the social aspects of learning. Learning often occurs through the support of others (e.g., Vygotsky, 1978). It is also situated in a specific social context that affects learning (e.g., Lave and Wenger, 1991). As a complement to this social perspective, there has been increased interest in considering individual identity formation (Rick et al., 2012). A fifth emphasis is on valuing multi-disciplinary perspectives. Unlike cognitive science, the term Learning Sciences is intentionally plural. Researchers from education, psychology, computing, design, anthropology, and other areas, contribute to the LS field. There is both an emphasis on inclusion but also valuing the individual perspectives and contributions of each field (or Learning Sciences) At the same time, there has been an emphasis on strengthening the core. There are increasingly more academic programs that directly align themselves with the Learning Sciences. The first of these, Northwestern University, accepted students in 1992. A sixth emphasis is on international participation. While the early conferences were held in the USA, recent conferences have included Australasia and Europe.

The year of 1991 saw both the first conference of the Learning Sciences (ICLS, organized at Northwestern University) and the founding of the Journal of the Learning Sciences (JLS, publisher Lawrence Erlbaum Associates, founding editor Janet Kolodner). The conference would next meet in 1994 and then continue at a biennial basis. Around the same time that the LS community was establishing itself, there began to be interest in supporting collaborative learning with computers (Stahl, Koshmann & Suthers, 2006), under the umbrella term Computer-supported Collaborative Learning (CSCL). This was particularly influenced by the arrival of computer networks and the Internet. This research movement was also theory driven, separating it from more general eLearning. It stressed collaboration among the students beyond simply splitting up a task: learners needed to negotiate and share meanings (Dillenbourg, 1999). The first use of the term for an event (often considered the start of CSCL) was at a NATO-sponsored workshop in Maratea, Italy in 1989. The first full CSCL conference was organized at Indiana University in 1995. It has continued at a biennial rate since then.

At the 2002 conference, the two fields were officially combined under the governing body of the International Society of the Learning Sciences (ISLS). The relationship had been close before as many of the foundational articles for CSCL were published in JLS. However, it should be noted that there is still some tension between CSCL and the LS. While LS is broader, it did not simply swallow CSCL. At the next conference, a CSCL Community inside ISLS was founded. In 2006, to further highlight the special designation of CSCL, the International Journal of Computer-Supported Collaborative Learning (ijCSCL, publisher Springer Verlag, founding editors Gerry Stahl and Friedrich Hesse) was established. Springer Verlag has also started a CSCL book series to cover specific topics relevant to CSCL in depth (first volume published in 2003).

Both conferences publish a variety of formats, including long, short papers and symposia. Though they are refereed (acceptance rates around 30%) and made publicly available in the ACM Digital Library, ISLS conference publications are not considered archived; authors retain their copyright and can publish the contents elsewhere. This decision was made so that authors could easily expand their conference contributions and submit them to the journals. Both JLS and ijCSCL have quickly grown to be highly influential journals in the education domain. Given the two journals and the conference proceedings, there is an established research literature on the LS. In addition, there have been introductory collections offered for both the Learning Sciences (e.g., Sawyer, 2006) and CSCL (e.g., Koschmann, 1996).

Human-Computer Interaction

Much like the LS, HCI is multidisciplinary in nature. It draws heavily from computer science, engineering, and design while appropriating theoretical and methodological approaches from cognitive science, psychology, sociology, anthropology, communication, and economics among others (Dix, Finlay, Abowd, & Beale, 2003). HCI, as a field, emerged in the late 1970s and early 1980s as personal computers became commonplace and the challenges of creating usable systems for non-experts became increasingly apparent. And, similarly to the LS, cognitive science and cognitive psychology played central roles in early HCI research as attempts were made to develop intricate models of interaction between users and machines (Card, Moran, and Newell, 1983).

HCI has been described as a community of communities (Carroll, 2009), which is reflected in the diverse array of conferences and sub-communities that self-identify with HCI. These conferences include Human Factors in Computing Systems (CHI), Computer-Supported Cooperative Work (CSCW), Symposium on

User Interface Software and Technology (UIST), Designing Interactive Systems (DIS), Interaction Design and Children (IDC), and Tangible, Embedded, and Embodied Interaction (TEI), to name a few. While these communities are diverse (with different emphases, values, and perspectives), they all have high standards for technological innovation.

One foundation of HCI is *usability*—the proposition that how usable a system is by its users has a profound effect on how useful it is. Even everyday objects can be systematically analyzed in terms of their usability (Norman, 1988). Unfortunately, even seemingly trivial objects (e.g., doors) are often designed without proper regard for usability, leading to unsatisfactory experiences. While there are established rules-of-thumb for considering usability (e.g., visibility, consistency, error recovery), one of the most fruitful techniques is testing the design with users (Nielsen, 1993). This concentration on human users is even reflected in the field's name. In its early days, the field was often termed CHI for computer-human interaction; the largest conference in the area is still abbreviated as CHI. In order to indicate the importance of considering the human, the field's name was changed to HCI, putting the human first.

Just as critiquing a movie is not sufficient for creating a movie, usability evaluation alone is not sufficient for designing usable interfaces. Hence, another focus of HCI has been on *interaction design* (Rogers, Sharp, & Preece, 2011). These techniques are generally user centered, with user involvement occurring early and often. One common technique is *prototyping*—quickly creating a low fidelity version of the system to test with users. Getting users involved early can expose problems early and thus significantly save on development time. Over time, the role that users play in the design process has been greatly expanded (e.g., test users, informants, design partners). Even children can be trained to be productive members of a design team (Druin et al., 1998). Design is an iterative process and there is a natural trade off between carrying out more iteration cycles and thoroughly evaluating each iteration. Interaction design favors the former over the latter. Even convenience samples, that do not represent actual end users for the system, can be useful in improving a design.

Over time, there has been a continual broadening of scope in HCI research driven by the expansion of digital technology and its role in everyday life. This, in turn, has led to a corresponding broadening of the unit of analysis—from individual users interacting with individual machines to populations of people interacting through and with technology on a global scale. While there are a few established journals, conferences are the premier venue for publication in HCI. It is not uncommon to find HCI researchers that target two conferences a year for their primary contributions. As a consequence, acceptance is highly competitive (often <20% at premier conferences) and the review process is taken very seriously. Larger conferences, such as CHI, have multiple committees to submit work to with different standards of contributions. Matching submissions to reviewers is often a sophisticated process and papers are usually evaluated by three to five reviewers. It is also not uncommon to have a multi-stage review process where authors are invited to a rebuttal (arguing that faults that reviewers find are not as damning as suggested) or even a revision cycle. Conference publications are considered archival, widely distributed (usually through the ACM digital library) and highly cited.

Synergy & Challenges

While they are separate fields, Learning Sciences and HCI have common roots. Both have a human focus, trying to solve real problems, usually in authentically complex contexts, and both make use advanced technologies to support that goal. Both have an activist tradition that current practice can be improved, and both have a strong bias towards conducting scientific studies and building theory around evidence.

Even though there is a noticeable connection between the fields, the strengths are underexploited. What HCI brings to the table is a focus on design, both what makes for an effective product and what makes for an effective design process. The community continually pushes on what is technologically possible while, at the same time, reimagining the relationships between people, machines, communities, and societies. HCI research on a new technology is likely to exist before it makes its way into Learning Sciences research. As HCI research tends to reflect on putting new technology into practice, learning scientists can appropriate this knowledge for their own developments. In addition, HCI evaluation and design techniques apply to Learning Sciences contexts and learning scientists would benefit from applying them to their own work.

What learning scientists bring to the table is a sophisticated understanding of learning. What makes for effective learning? In comparison to other human-computer interface domains where efficiency or usability can be more easily quantified, measuring learning is complex. Facts, cognitive skills, metacognitive skills, communication / collaboration skills and epistemologies are all worthy of consideration. Motivation too may be more salient in a learning context (Soloway, Guzdial, & Hay, 1994). What are the important problems in education and learning that need to be addressed? Using a technology to address a learning goal that is already well addressed through other means, might contribute to our understanding of the technology but does little to improve education. What theories of learning and instruction do we build upon? Just as there are guiding theories from HCI about what makes a usable design or what makes for an effective design process, there are established theories of how people learn and what practices can best facilitate those. A standard HCI practice is applying technology to solve an important problem. Learning can be such a domain and learning scientists can reflect on which problems are worth solving. As a starting point, the research communities could benefit by being more aware of each other's perspectives and existing contributions (i.e., cross-disciplinary communication). Building on that would facilitate cross-disciplinary collaboration. Over time, this might even promote interdisciplinary work, where there are simultaneous contributions to both fields.

The Workshop: Purpose and Contribution

The purpose of this workshop is to deepen the community's shared knowledge and to better the relationship between the fields. This workshop aims to explore how we can better support work at the intersection of the fields. Some questions the workshop intends to address include:

1. How can the Learning Sciences benefit from HCI methods (e.g., usability, rapid prototyping, user-centred design)?
2. What can the Learning Sciences learn from the HCI research field (e.g., being aware of related work)?
3. How do we disseminate answers for the first two questions to the larger Learning Sciences field?
4. How do we better support HCI researchers with some interest in Learning Sciences?
5. How do we better support Learning Sciences researchers with some interest in HCI?
6. How do we better support true interdisciplinary researchers?
7. Are there possibilities to move this conversation forward and perhaps forming a stronger community at the intersection of the fields (SIG, community, CSCL special issue)?

The workshop is based on critical issues in interdisciplinary HCI / LS work or visions of how to advance the relationship between HCI and LS both presented by the participants of the workshop. It is expected that the workshop will produce:

1. Critical discussion and collective analysis regarding case studies described in the accepted papers.
2. The position papers will be published in separate proceedings of the workshop that will be available at the workshop's website.
3. Generation of a summarising paper (by workshop organisers) based on the workshop proceedings after the workshop.
4. Eventual joint publication of the papers presented in the workshop and an overview of the current tendency of the intersection of HCI and LS in a Journal special issue (to be defined).

Organizers

Jochen Rick's research interests lie at the intersection of learning, collaboration and new media. He creates innovative and effective educational technologies and researches their value in authentic contexts. His current research focuses on supporting co-located collaborative learning with interactive surfaces. In 2010, he joined the new Department of Educational Technology, Saarland University as a research associate / instructor, contributing a computer science perspective to an interdisciplinary department. Before that, he spent three years as a research fellow at the Open University in Yvonne Rogers's HCI group. In 2007, he received a Ph.D. in Computer Science (area of Learning Sciences and Technology) from the Georgia Institute of Technology; his dissertation research, supervised by Mark Guzdial, investigated the role that personal home pages play in academia. His work on CoWeb (Collaborative Websites) was the first research on using wikis to support learning in university classes.

Michael Horn in an assistant professor at Northwestern University, USA with a joint appointment in Computer Science and the Learning Sciences. He received his PhD in Computer Science and Human-Computer Interaction from Tufts University. Michael's research explores the role of emerging interactive technology in the design of learning experiences. His projects include the design of a tangible computer programming language for use in science museums and early elementary school classrooms; and the design of multi-touch tabletop exhibits for use in natural history museums. Michael has presented work at cross-disciplinary conferences including Interaction Design and Children (IDC), Tangible, Embedded, and Embodied Interaction (TEI), Human Factors in Computing Systems (CHI), ICLS, and AERA; he is on the editorial board for the Journal of Technology, Knowledge, and Learning; and he is the program committee for ACM Interactive Tabletops and Surfaces (2012 and 2013). Michael co-organized a workshop on Technology for Today's Family at CHI 2012.

Roberto Martinez-Maldonado is a PhD candidate in the Computer Human Adapted Interaction Research Group at The University of Sydney, Australia. His research focuses on analyzing data generated when groups of students collaborate using shared devices to foster teachers' awareness of their learning processes.. His research grounds on principles of HCI, CSCL, Educational Data Mining and Learning Analytics; he makes use of a number of technologies including multi-touch interactive tabletops, tablets, kinect sensors and databases. He has presented work at interdisciplinary conferences that include Intelligent Tutoring Systems (ITS), Artificial Intelligence in Education (AIED), Interactive Tabletops and Surfaces (ITS) CSCL, ICLS and

Educational Data Mining (EDM). He lead the organisation of the workshop held in conjunction with ICLS 2012 titled Digital Ecosystems for Collaborative Learning. Contact: about.me/RobertoMartinezMaldonado

Endnotes

†Website: https://surfaclearning.org/HumanComputerInteraction

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Measuring Collaborative Thinking Using Epistemic Network Analysis

Abstract: Learning in the 21st century means thinking in complex and collaborative ways that are situated in a real world context. In this workshop we propose to convene a community of researchers who are examining (or interested in examining) complex thinking in communities of practice using epistemic network analysis (ENA). Originally designed to assess epistemic frames—collections of skills, knowledge, identities, values, and ways of making decisions—in virtual game environments, ENA is now being used more generally to quantify the structure of connections that constitute complex thinking as they manifest in discourse. Patterns of connections between elements of discourse are one important feature of action in any domain, and ENA can help researchers quantify and visualize the development of such connections over time. The goal of this pre-conference workshop is to explore the usage of ENA in a diverse array of domains, including log files, video game data, classroom teacher discourse, interview transcripts, and neuroscience imaging. We propose to (1) introduce new users to this method, (2) provide further training and insight for those already using ENA, and (3) develop a broader community of users and, as a result, create opportunities for the advancement and improvement of ENA. Currently, we have ten researchers from ten institutions interested in using ENA with their collected data, and we propose a workshop with a total of 20 participants, including current ENA users and those interested in learning more about the technique.

Organizers

David Williamson Shaffer is a professor at the University of Wisconsin-Madison in the departments of Educational Psychology and Curriculum and Instruction, and a Game Scientist at the Wisconsin Center for Education Research. He is the chief PI on the Epistemic Games grants.

Chandra Hawley Orrill is an assistant professor of STEM Education at the University of Massachusetts Dartmouth. She is also a Research Scientist in the Kaput Center for Research and Innovation on STEM Education. Dr. Orrill is PI on an NSF CAREER award titled Coherence as the Basis for Understanding Teachers' Mathematical Knowledge for Teaching in which she is relying on ENA.

Golnaz Arastoopour is a graduate student in learning sciences in the Epistemic Games research group at the University of Wisconsin-Madison working on the Nephrotex project (an engineering epistemic game) and Epistemic Network Analysis. She is interested in how games and simulations are effective and increase student engagement in STEM fields.

Theoretical Background

Learning in the 21st century means thinking in complex and collaborative ways that are situated in a real world context (National Research Council, 2011). Yet we cannot teach complex thinking effectively unless we can measure and clearly show whether or not it has been developed. In this workshop we propose to convene a community of researchers who are examining (or interested in examining) complex thinking in communities of practice using *epistemic network analysis* (ENA).

One way we think of complex and collaborative thinking is in terms of epistemic frame theory, which suggests that learning to solve complex problems comes from being a part of a community of practice—a group of people that share ways of working, thinking, and acting in the world. Any community of practice has a culture (D W Shaffer, 2006; D W Shaffer et al., 2009): a structure composed of skills (the things that people within the community do); knowledge (the understandings that people in the community share); values (the beliefs that members of the community hold); identity (the way that members of the community see themselves); and epistemology (the warrants that justify actions or claims as legitimate within the community). This collection of skills, knowledge, values, identity, and epistemology forms the epistemic frame of the community (Chesler, Arastoopour, D'Angelo, Bagley, & Shaffer, 2012; David Williamson Shaffer, 2006). This theory has been used in developing and testing STEM learning games in engineering, science journalism, land use planning, and other fields (Bagley, 2011; Hatfield, 2011; Svarovsky & Shaffer, 2006).

ENA has been developed as a tool that models the connected understanding that characterizes complex learning in communities of practice in terms of epistemic frames. Although originally designed to assess epistemic frames in virtual game environments, ENA is now being used more generally to quantify the *structure of connections that constitute complex thinking as they manifest in discourse*. Patterns of connections between elements of discourse are one important feature of action in any domain, and ENA can help researchers quantify and visualize the development of such connections over time.

In ENA, discourse is coded for the presence of key elements in the domain. For any two elements, the strength of their association in an epistemic network is computed based on the *frequency of their co-occurrence in discourse*—where discourse in this sense refers to recorded activity, whether verbal utterances or other actions. Using this technique, we can quantify the epistemic network of a person or group, and the evolution of such a network over time. This representation of the linkages between elements over time quantifies the development of a network. Changes in networks (and a possible convergence towards an ideal configuration) can be measured by calculating the distance between individual networks. In this way, ENA can associate key changes in complex and collaborative thinking with specific activities that learners undertake.

ENA on Teacher Interviews

In one study, Orrill (Orrill & Shaffer, 2012) investigated how middle school teachers of different mathematical abilities make sense of proportional reasoning. She coded one question from a clinical interview protocol for elements relevant to the domain, such as understanding ratio concepts, ratio/fraction relationships, interpreting diagrams, and problem solving skills. As hypothesized, there were substantial differences between the higher skilled (Figure 1) and the lower skilled (Figure 2) network graphs.

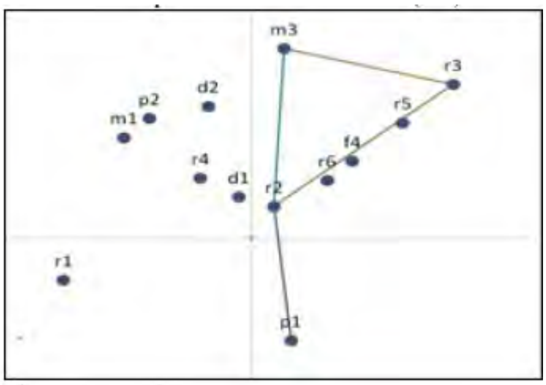

Figure 1. High skilled teacher's network graph

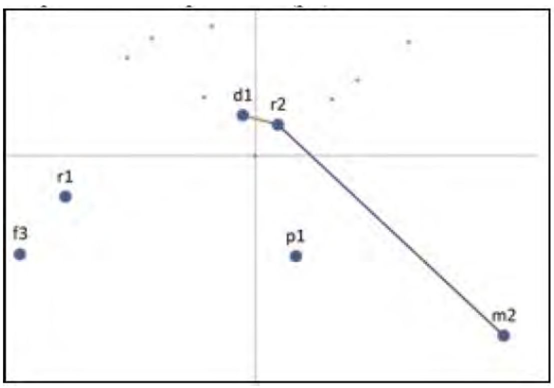

Figure 2. Low skilled teacher's network graph

The higher skilled teacher relies on ratio reasoning (r2, r3) and problem solving skills (p1) to make sense of ratios. In contrast, the lower-skilled teacher relies on the diagram (d1), ratio reasoning (r2), and ratio/fraction relationship (m2). The key finding was that the higher skilled teacher's network is more connected (4 links and 4 nodes) than the lower skilled teacher's network (2 links and 3 nodes). Results from this study show that epistemic network analysis can be used to distinguish between varied levels of complex thinking skills in a domain.

ENA in an Engineering Virtual Game

In another study, Arastoopour (Arastoopour, 2012) examined data from an engineering virtual game. In particular, she examined whether players in the game who made more connections between the skills, knowledge, and epistemology of engineering *design* and other elements of engineering practice (ENA Results) showed positive change in *positive view of engineering careers* (Outcome Measures). The game recorded discourse data and the discourse was coded for engineering skills, knowledge, values, identity, and epistemology elements. The measurement algorithm for the resulting dataset had a second dimension (ENA 2) where items that loaded negatively were related to data analysis and items that loaded positively were related to engineering design. Figure 3 shows a student who has a high ENA 2 score and makes a high number of connections with engineering design and other elements. Figure 4 shows a student who has a low ENA 2 score and makes a low number of connections with engineering design and other elements.

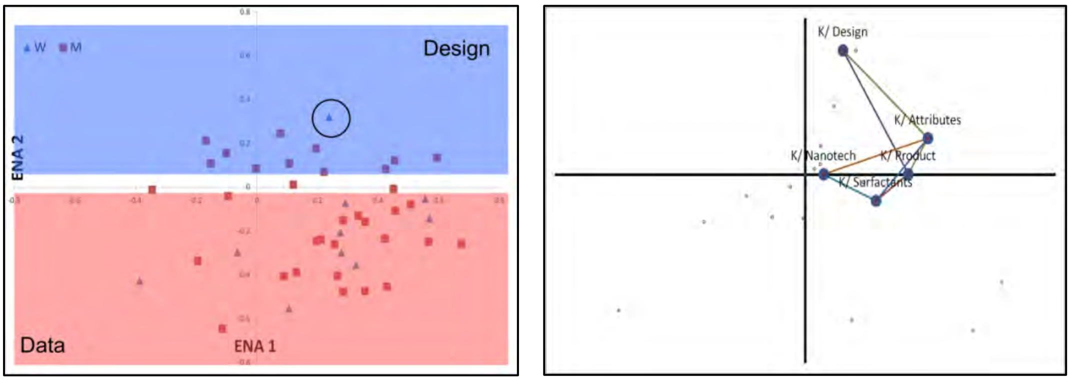

Figure 3. A student who had a **high** ENA 2 final score (made connections with design in their networks) represented as a point in high multidimensional space and as an epistemic network representation

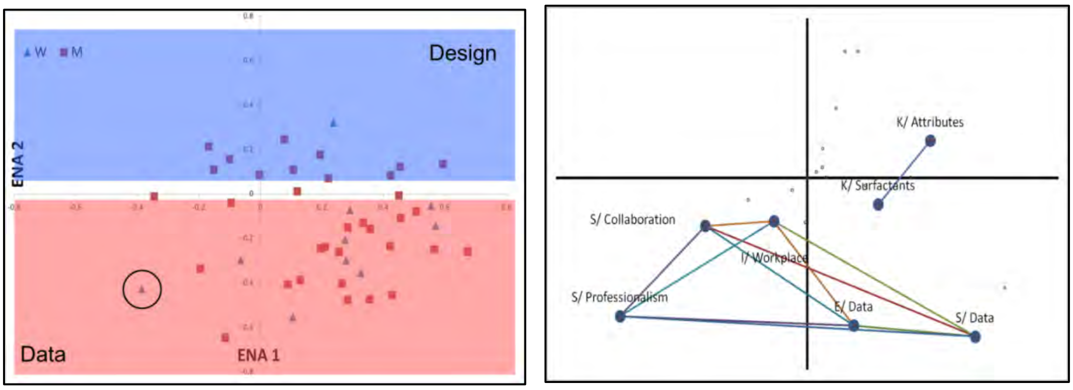

Figure 4. . A student who had a **low** ENA 2 final score represented as a point in high multidimensional space and as an epistemic network representation

Pre and post survey data on students' views on engineering careers were also collected. Using a regression model, we determined that students in the game who *made more connections among elements of engineering practice* showed increased positive change from pre to post survey on their view of *engineering careers* (Figure 5). In other words, changes in ENA 2 significantly predicted changes in post scores when controlling for pre scores (β = 1.789, $p < .05$, $R^2 = .411$).

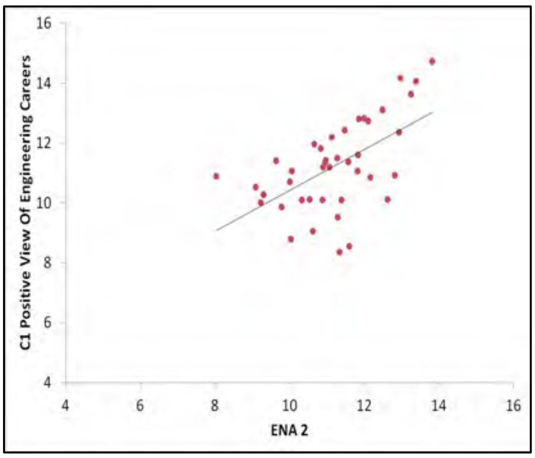

Figure 5. Players' final ENA scores correlated with survey scores on positive view of engineering careers

Results from this study demonstrated that ENA was able to link forms of participation in learning activities to specific educational outcomes.

Objectives

Although ENA has already been used in virtual game environments and with teacher interview protocols, we propose to explore the use of ENA in a variety of disciplines such as neuroimaging, classroom behavior, online discussion forums, and video game data. For example, in the field of neuroscience, the brain can be thought of as a large-scale network processing multiple levels of information such as neurons, local circuits, and systems of brain areas. Work is underway to use ENA to measure brain activity connections from data collected in neuroimaging techniques. Another area under exploration is discussion forums for online learning communities. These communities typically have learning objectives and ideal patterns of connections that students are supposed to draw between concepts. ENA is being used to measure the development of complex thinking that occurs in the collaborative discourse environment.

The goal of this pre-conference workshop is to explore the usage of ENA in a diverse array of domains, including log files, video game data, classroom teacher discourse, interview transcripts, and neuroscience imaging. We propose to (1) introduce new users to this method, (2) provide further training and insight for those already using ENA, and (3) develop a broader community of users and, as a result, create opportunities for the advancement and improvement of ENA. Currently, we have ten researchers from ten institutions interested in using ENA with their collected data, and we propose a workshop with a total of 20 participants, including current ENA users and those interested in learning more about the technique.

Contributions

Our approach beings with using ENA as a tool for measuring professional thinking development in virtual game environments, but we propose that ENA can be used to measure the connections that represent complex thinking as they appear in discourse *in a variety of domains*.

We expect that participants in this workshop will leave with a theoretical and practical understanding of ENA and as result can apply the method to their future work. Ultimately, ENA will be able to analyze coded data from a variety of sources, including virtual games, including online log files and discussion forums, video game data, classroom teacher discourse, interview transcripts, and neuroscience imaging. Our project includes a toolkit dissemination plan that deliberately targets a wide audience of researchers, materials developers, practitioners, policymakers, and the public.

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Workshop: Across Levels of Learning: How Resources Connect Levels of Analysis

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Abstract: CSCL research typically involves processes at the individual, small-group and community units of analysis. However, CSCL analyses generally each focus on only one of these units, even in multi-method approaches. Moreover, there is little data-based analysis of how the three levels are connected, although it is clear that such connections are crucially important to understanding learning in CSCL contexts. This workshop will explore one possible way of doing research about how the levels of individual learning, group cognition and community knowledge building are connected: through a focus on emergent *interactional resources*, which can mediate between the levels.

Workshop Theme: The Problem of Connecting Levels

Learning, cognition and knowledge building can be analyzed at multiple units of analysis. For instance, analyses of CSCL are often conducted on one of three levels: individual learning, small-group cognition or community knowledge building. This tri-partite distinction is grounded in the nature of CSCL. With its focus on collaborative learning, CSCL naturally emphasizes providing support for dyads and small groups working together. In practice, CSCL small-group activities are often orchestrated within a (physical or virtual) classroom context by providing some initial time for individual activities (such as background reading or homework practice) followed by the small-group work and then culminating in whole-class sharing of group findings. Thus, the typical classroom practices tend to create three distinguishable levels of activity. Often, the teacher sees the group work as a warm-up or stimulation and preparation for the whole-class discussion, facilitated directly by the teacher. Conversely, the importance of testing individual performance and valuing individual learning posits the group work as a training ground for the individual participants, who are then assessed on their own, outside of the collaborative context. In both of these ways, group cognition is treated as secondary to either individual or community goals. By contrast, the role of intersubjective learning is foundational in Vygotsky (1930/1978), the seminal theoretical source for CSCL. Regardless of which is taken as primary, the three levels are actualized in CSCL practice, and the matter of their relative roles and connections becomes subsequently problematic (Dillenbourg et al., 1996; Rogoff, 1995; Stahl, 2006).

While these different units, levels, dimensions or planes are intimately intertwined, research efforts generally each focus on only one of them, and current analytic methodologies are designed for only one (Stahl, 2013; Suthers et al., 2013). Furthermore—and most importantly for this workshop—there is little theoretical understanding of how the different levels are connected. To the extent that CSCL researchers discuss the connections among levels, they often rely upon commonsensical notions of socialization and enculturation, popularizations of traditional social science. There are no explicit empirical analyses of the connections, and it is even hard to imagine where one would find data that would lend itself to conducting such analyses (Stahl et al., 2012).

The individual unit of analysis is the traditional default in the learning sciences and in cognitive psychology. It is supported by widespread training of researchers in the methods of psychology and education. In the era of cognitive science, analysis made heavy usage of mental models and representations (Gardner, 1985). With the "turn to practice" (Lave & Wenger, 1991; Schatzki, Knorr Cetina & Savigny, 2001), the focus shifted to communities-of-practice. Group cognition lies in the less-well-charted middle ground (Stahl, 2006). It involves the semantics, syntactics and pragmatics of natural language, gestures, inscriptions, etc. These meaning-making processes involve inputs from individuals, based on their interpretation of the on-going context (Stahl, 2006, esp. Ch. 16). They also take into account the larger social/historical/cultural/linguistic context, which they can reproduce and modify (Stahl, 2013).

This workshop will explore ways in which the connections between the individual, group and community planes take place through the mediation of *interactional resources*. To provide specificity and to ground the presentation in empirical data, the workshop will consider the resources that appear in recorded examples of CSCL settings.

Computer technologies play a central role in mediating the multi-level, intertwined problem-solving, learning and knowledge-building processes that take place in CSCL settings. From a CSCL perspective, innovative technologies should be designed to support this mediation. This involves considering within the socio-technical design process of collaboration environments how to prepare groups, individuals and communities to take advantage of the designed functionality and to promote learning at all levels.

Workshop Theory: The Emergence of Interactional Resources

While we are interested in linguistic interactional resources in this workshop, it may be helpful to first consider the more intuitive case of a physical resource. A ramp or bridge often creates a possibility that did not otherwise exist for going from one level to another at a given point. To go from a local road to a limited-access superhighway, one must first find an available on-ramp. To cross a river from one side to the other, one may need a bridge. This is the individual driver's view. From a different vantage point—the perspective of the resource itself—the creation of a ramp or the building of a bridge "affords" connecting the levels (Dohn, 2009).

By "affords," we do not simply mean that the connecting is a happy characteristic or accidental attribute of the bridge, but that the bridge, by its very nature and design, "opens up" a connection, which connects the banks of the river it spans. This view of artifacts was largely introduced in the philosophy of Heidegger and later became influential in CSCL through various theories influenced by Heidegger. This transformation of perspective away from a human-centric or individual-mind-centered approach became characteristic for pioneering theories in the second half of the 20th Century, including recent theories of situated and distributed cognition. It is a shift away from the individualistic, psychological view to a concern with how language, tools and other resources of our social life work. It is a post-cognitive move since it rejects the central role of mental models, representations and computations. The things themselves have effective affordances; it is not just a matter of how humans manipulate models in which the things are re-presented to the mind.

The analytic focus and even the locus of agency are shifted from the individual mind to tools, artifacts, instruments, discourse and inscriptions. In ethnomethodology, Garfinkel and Sacks (1970) followed Wittgenstein's (1953) linguistic turn to focus on the language games of words and the use of conversational resources (Koschmann, Stahl & Zemel, 2004). In distributed cognition, Hutchins (1996) analyzed the encapsulation of historical cognition in cultural artifacts. In actor-network theory, Latour (1990; 1992; 2007) uncovered the agency of various kinds of objects in how they move across levels in enacting social transformations. Recently, Rabardel (Lonchamp, 2012; Overdijk et al., 2012; Ritella & Hakkarainen, 2012) analyzed the genesis of socio-technical instruments, which only gradually become useful as they are adapted and enacted in practice.

Our proposal in this workshop to use the term "resources" is intended to carry forward into the 21st Century these groundbreaking approaches into the study of how the various planes of human interaction are connected. The phrase "interactional resource" is proposed as an inclusive expression for all the kinds of things that can be brought into discourse. Vygotsky (1930/1978) used the term "artifact" to refer to both tools and language as mediators of human cognition; we prefer to use the broader term "resource" as it has more recently been used in sociocultural analysis (Furberg, Kluge & Ludvigsen, 2013; Linell, 2001; Öner, 2013; Suchman, 1987) for entities referenced in discourse. Like artifacts, resources are often identifiable units of the physical world (including speech and gesture) that are involved in meaning-making practices—spanning the classical mind/body divide.

A central research issue for CSCL is how collaborative knowledge building takes place. The main problem seems to be to understand the roles of both individual cognition and societal institutions in small-group meaning-making processes. We do not mean to reify different levels or processes as necessarily having some kind of independent existence outside of our analyses, but to suggest that there are important constraints between different phenomena and possible flows of influence across levels. We distinguish between levels and we try to identify resource-mediating connections between them in order to operationalize the infinitely complex and subtle matter of collaborative knowledge building for purposes of concrete analytic work by CSCL researchers.

Some researchers, such as ethnomethodologists, argue against distinguishing levels. However, the view of levels of analysis in this workshop may actually be consistent with ethnomethodology. For instance, in their introduction to ethnomethodologically inspired Conversation Analysis (CA), Goodwin and Heritage (1990, p. 283)—two of the writers most explicit about the theory underlying ethnomethodological studies—open with the following claim: "Social interaction is the primordial means through which the business of the social world is transacted, the identities of its participants are affirmed or denied, and its cultures are transmitted, renewed, and modified." This statement implicitly distinguishes social interaction, individual identities and community cultures—asserting the tight connections between them and a priority to the first of these. Social interaction typically takes place in dyads and small groups, so interaction analysis can be considered to be conducted at the small-group unit of analysis. Although CA, as a branch of sociology, refers to community-level social practices and linguistic resources, its case-study analyses involve interactions in dyads or small groups. CSCL researchers focus on small groups, but also want to analyze the levels of the individual and of the culture as such—e.g., the individual identities and learning changes or the cultural practices and institutional forces.

CSCL sequential small-group discourse brings in—through indexical references, as described below—resources from the individual, small-group and community planes and involves them in procedures of shared meaning making. This interaction requires co-attention to the resources and thereby shares them among the participants. The process results in generating new or modified resources, which may then be retained at the various planes. The resources that are brought in and those that are modified or generated often take the form of designed physical artifacts and adopted elements of language. In other words, "small groups are the engines of knowledge building. The knowing that groups build up in manifold forms is what becomes internalized by their members as individual learning and externalized in their communities as certifiable knowledge" (Stahl, 2006, p. 16). The question of how the local interactional resources that mediate sequential small-group interaction are related to large-scale socio-cultural context as well as to individual learning is an empirical question in each case. There are likely many ways these connections across levels take place, and they involve mechanisms that are not apparent to participants.

Sawyer (2005, p. 210f) argues that we can conceptualize the general level-bridging processes as forms of "collaborative emergence"—involving both ephemeral emergents and stable emergents: "During conversational encounters, interactional frames emerge, and these are collective social facts that can be characterized independently of individuals' interpretations of them. Once a frame has emerged, it constrains the possibilities for action." Sawyer's theory of ephemeral and stable emergents suggests a relationship among different kinds of interactional resources. While Sawyer's analysis addressed a much broader sociology of social emergence, we have confined and adapted it to the concerns of CSCL. What is most relevant in his theory is the view of emergence arising out of the subtle complexities of language usage and small-group interaction, rather than from the law of large numbers, the interaction of simple rules or the chaotic behavior of non-linear relationships. The vast variety of interactional emergents form an intermediate level of analysis between the level of individuals and the level of community structures, providing a dynamic and processual understanding of social structures and infrastructures.

In this theory, interaction is taken as being based on an "indexical ground of deictic reference" (Hanks, 1992). This means that the "common ground" (Clark & Brennan, 1991)—which forms a foundation for mutual understanding of what each other says in conversation—consists of a shared system of *indexical-reference resources*, such as deictic pronouns, which are used to point to unstated topics or resources. Interactional resources, which can be indexically referenced in the interaction, may undergo a process like Rabardel's (Rabardel & Beguin, 2005; Rabardel & Bourmaud, 2003) instrumental genesis: they may initially be constituted as an object of repeated discussion—an interaction frame (Goffman, 1974)—which we might call a *reified resource*, something capable of being picked out as having at least an "ephemeral-emergent" existence. Over time, continued usage can result in a *sedimented resource*, something whose existence has settled into a longer-term "stable-emergent" form. A sedimented resource is then susceptible to being taken up by a larger community as an *institutionalized resource* within a structured network of such resources, as in Latour's social-actor networks (Latour, 2007), contributing to the socio-cultural-historical context surrounding the interaction: not only referencing it, but partially reproducing it. On the other hand, interactional resources at various degrees of reification can also be taken up into the individual understanding of community members as *personalized resources*, integrated more or less into the intra-personal perspective of one or more group members. The personalization of previously inter-personal resources by individuals renders them into resources that can be referenced in activities of individual understanding—corresponding to processes of micro-genesis in Vygotskian internalization.

The various components of this view of interactional resources have been hinted at in previous theoretical contributions grounded in empirical examples. The term "reification" goes back to Hegel's philosophy of mediation (Hegel, 1807/1967). It has been applied to the formation of mathematical concepts by Sfard (Sfard, 2000; 2008; Sfard & Linchevski, 1994). Livingston (1999) differentiated discovering a mathematical proof from presenting a proof; a transformational process takes place, in which the byways of exploration and possibly even the key insights are suppressed in favor of conforming to the institutionalized template of formal deductive reasoning. Netz (1999) (see also the review by Latour, 2008) documented the important role of a controlled (restricted) vocabulary in the development, dissemination and learning of geometry in ancient Greece. Analogously, Lemke (1993) argued that learning the vocabulary of a scientific domain such as school physics is inseparable from learning the science. Vygotsky (1930/1978, esp. pp. 56f) noted that the micro-genetic processes of personalizing a group practice into part on one's individual understanding—which he conceptually collected under the title "internalization"—are lengthy, complex, non-transparent and little understood. These seminal writings name the processes of reification, sedimentation, institutionalization and personalization of interactional resources; their empirical investigation remains as a major challenge for future CSCL research.

Workshop Contribution: The Analysis of Evolving Resources

Analyses of CSCL research show that few studies have bridged multiple levels of analysis (Arnseth & Ludvigsen, 2006; Jeong & Hmelo-Silver, 2010). Yet the desired CSCL research agenda (Krange & Ludvigsen, 2008; Stahl, Koschmann & Suthers, 2006; Suthers, 2006) calls for a study of representational artifacts and other resources that traverse between individual, small-group and community processes to mediate meaning making. The preceding sketch of emergent forms of evolving resources could be taken as a refinement of the research agenda for the field of CSCL: a hypothesis about how levels in the analysis of learning are connected and an agenda for exploration. This is intended only as a starting point, and we welcome the presentation of further ideas—grounded in CSCL case studies—that will guide the field in connecting levels of analysis.

Workshop position papers should begin that undertaking. They should present examples of interactional resources in computer-mediated small-group discussions. Future research will need to log the use of resources by teachers and students in order to analyze how resources connect levels of learning in CSCL settings. We need to track individual and group learning as resources and practices from community levels are taken up in sequential small-group interaction. Perhaps we will witness the formation of local practices and group interactional resources, which can influence individual and community levels over time. In these ways, we will study resources for connecting levels of learning in CSCL.

More generally, through analysis of the nature and work of interactional resources in case studies of a broad variety of CSCL interactions, the CSCL research community can expect to reach a better understanding of the nature of different levels of analysis in CSCL research and how the levels may be connected in terms of their mediation by diverse resources. Gradually, we will discover how resources are enacted, understood, shared, designed, adapted and preserved—and how they mediate connections among levels of learning through social interaction.

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Volume 2

Doctoral Consortium Papers

The CSCL 2013 Doctoral Consortium

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Summary

The CSCL 2013 Doctoral Consortium Workshop provides an opportunity for advanced Ph.D. students to share their dissertation research with their peers and a panel of faculty serving as mentors. Participants will engage in collaborative inquiry and scholarly discourse to improve their dissertation work and to advance their understanding of CSCL and the Learning Sciences. The Doctoral Consortium Workshop mainly aims to (1) provide an opportunity for participants to reflect on their dissertation research and to identify problems/issues for further discussion and inquiry; (2) provide a setting for participants to contribute ideas as well as to receive feedback and guidance on their current research; (3) provide a forum for discussing theoretical and methodological issues of central importance to CSCL and the Learning Sciences; (4) develop a network of supportive scholars in CSCL across countries and continents; (5) contribute to the conference experience of participating students through interaction with other participants, mentors and organizers; (6) support young researchers in their effort to enter the Learning Sciences research community. The Doctoral Consortium Workshop will last for 1.5 days scheduled during the pre-conference events. Doctoral Consortium Workshop activities are organized around small-group interactions. During the workshop, participants will first present their research briefly to familiarize each other with their dissertation project and highlight specific aspects they would like to have further discussion on or receiving input on how to approach them; intriguing issues and tensions for CSCL research generally; methodological problems that other Ph.D. students are likely to be confronted with, or issues that have the potential of stimulating discussions of theoretical and methodological significance. Then, based on the common issues and themes identified (theoretical models, research design and questions, pedagogy and technology, data collection, methods of analysis etc.) participants will form small groups supported by an expert mentor, to engage in further inquiry and discussion. Participants will work on the various problems and issues identified making reference to their own dissertation project and the broader field of CSCL and the Learning Sciences. After the small group interactions, participants will report their progress and new questions to the whole group. Plans for joint activities in the future will be discussed as well.

Note: This concept and description of the Doctoral Consortium is based to a large extent on the Call for Papers for the Doctoral Consortium at CSCL 2011 written by Kris Lund, Carol Chan, and Chris Hoadley.

Collaborative Groups as Context for Negotiation of Competence: Peers Co-constructing Competence and Opportunities for Participation

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Abstract: While literature on status hierarchies highlights imbalanced interactions in groups, observing moment-to-moment interactions and discourse moves can contribute to our understanding of inequity. We should consider whether group members truly accept less influential roles or this is instead a product of competence negotiation. These three studies will examine whether competence negotiation leads to stable patterns of interaction that solidify inequitable access to participation over time by integrating individual- and group-level processes.

Pilot work for these studies builds off Gresalfi and colleagues' systems of competence. Consideration was given to whether negotiation of competence could produce and potentially reinforce differential access to participation through determinations of whose contributions would be included in group work. Competence negotiation processes in conjunction with socially shared regulation afforded and constrained opportunities to participate. Findings indicated that other-regulators set the tone for competence negotiation in collaborative groups: facilitative other-regulators promoted positive valuing of peers' contributions and treatment of peers as competent (e.g. advocating for others' contributions to be included, intervening in instances of harsh rejection, explicitly acknowledging the value of groupmates' contributions) while directive other-regulators regularly conveyed negative competence messages by being dismissive, ignoring contributions, and explicitly diminishing groupmates' competence (e.g. "How are you in Honors Literacy?"). Participation opportunities were shaped by these interactions: directive other-regulation led to reduced opportunities to contribute.

The following three studies emerge from the pilot research. The first study will be a qualitative examination of how participation is afforded and constrained by negotiation of competence within a collaborative group and whether access to participation and roles changes over time. The second study will consider students' experiences with competence negotiation within their groups. The third and final study will explore individual differences as a source of explanation for differences in competence negotiation. Achievement goal endorsement and groupwork attitude measures will be matched with video observations of groups to examine the relationships between students' perceptions and observed competence negotiation. Perceptions of one's groupmates, beliefs about groupwork tasks, and achievement goals may explain how competence threats arise and promote competence positioning by group members.

The Role of Software in Environmental Conflict Resolution: How Did MarineMap Facilitate Collaborative Learning in California's MLPA Initiative?

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Abstract: Facing contentious decisions, environmental agencies increasingly engage in collaborative problem solving efforts that require joint knowledge-building among diverse stakeholders. My mixed-methods research uses a case study of a tool called MarineMap, an application developed to aid stakeholders in siting marine protected areas along California's coastline. By analyzing video of public meetings, I examine micro-scale knowledge building processes to understand how visualization software influences the creation of group meaning and decision-making in collaborative environmental governance.

Goals and Background

Facing complex, contentious decisions, federal and state environmental agencies increasingly engage diverse groups of stakeholders in collaborative problem solving efforts that seek mutually-agreeable outcomes. (Wondolleck & Yaffee, 2000; Balint et al, 2011). Such governance processes necessitate forming "knowledge building communities" (Scardamalia & Bereiter, 1993). Seeking to enhance knowledge building, agencies have become enthusiastic about using information technology to help groups access data, generate ideas, learn about others' views, and consider tradeoffs. They have begun to experiment with a variety of tools including visualization software, but thus far little attention has been paid to empirically investigating the mechanisms by which such software influences learning. Addressing this gap, my research examines micro-scale knowledge building processes in collaborative environmental governance. By investigating what Stahl et al (2006) call "doing learning", my research seeks to move beyond current frameworks for understanding collaborative governance that tend to focus on the legal, social and emotional aspects of negotiation (e.g. Arrow et al 1995) or investigate macro-scale factors such as how the network structure of participants impacts learning outcomes in a public policy process (e.g. Gerlak & Heikkila, 2011).

Case Study and Methodology

My dissertation is a detailed investigation of an innovative software application called MarineMap. This tool was developed by researchers at UC-Santa Barbara, Ecotrust, and The Nature Conservancy to help stakeholders including state agencies, scientists, fisherman, environmental organizations, and citizens of coastal communities decide where to locate marine protected areas (MPAs) in California. Unlike similar decision support tools, MarineMap is one of the first designed to be used by stakeholders rather than specialized technical users. Anecdotally, MarineMap is widely regarded as a success that allowed people with divergent views to design a set of mutually-acceptable marine protected areas. In 2010 it was awarded one of the US Institute for Environmental Conflict Resolution's inaugural "Innovation in Technology and Environmental Conflict Resolution" prizes. However, little is understood about the precise learning mechanisms by which the tool enabled participants to build shared knowledge.

My dissertation as a whole is making use of five interwoven data streams: (a) analysis of documents produced by participants (e.g. draft proposals), (b) software logs that have allowed me to analyze trends in intensity of use, (c) an online survey of participant-reported behavior (e.g. % of time spent using tool alone vs. in a group), (d) semi-structured interviews with tool users following up on survey results, and (e) analysis of video recordings of group use of MarineMap in public meetings, which is the aspect I will primarily be focusing on at the Doctoral Consortium.

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Supporting Assessees' Sense-Making of Peer Feedback to Foster Feedback Uptake in Online Peer Assessment

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Abstract:
This study aims at improving students' writing skills in a peer assessment setting. Seventy-three students participated in an online writing task. We investigated whether providing sense-making support during feedback reception leads to increased feedback uptake, better revisions, and improved writing skills, as compared to a condition without sense-making support. Results will contribute to theory building in peer assessment and writing research.

Theoretical Background

Writing is an important skill for university students, but learning to write academic texts is challenging. Therefore, receiving feedback is important. Feedback can be provided through peer assessment, however, students often fail to take up peer feedback, because they don't sufficiently engage in sense-making processes around the feedback (Van der Pol, Van den Berg, Admiraal, & Simons, 2008). And even if they try to deal with the feedback, they may have problems managing it (Boero & Novarese, 2012). Successful feedback uptake requires assessees to gain a coherent understanding of the feedback. Support is needed to help students in making sense of feedback with the goal to improve feedback uptake, revisions and ultimately writing skills.

Substantial research shows that providing feedback by assessing products created by peers, leads to learning gains (Topping, 2003). Yet, there is little empirical evidence that receiving peer feedback leads to learning gains as well (Van der Pol et al., 2008; Gielen, Peeters, Dochy, Onghena, & Struyven, 2010). This project aims at focussing on the assessee and shedding light on the question: Does supporting sense-making of peer feedback increase assessees' feedback uptake and writing skills? We expect that providing assessees with sense-making support during feedback reception will improve feedback uptake and writing skills.

Method

Participants: Seventy-three freshmen (♂16, ♀57) participated as part of their regular course activities.

Design and Procedure: We conducted an experimental study with sense-making support (SMS) as independent variable. Participants were randomly assigned to a SMS condition and a No-SMS condition. Over a course of 10 days, students participated in an online writing task: they created essays of maximally 650 words, received feedback, and revised their essays. The feedback included 10 comments based on five writing criteria (2 comments per criterion), for example: logic of argument. Participants were informed that feedback was given by peers, however, it was given by trained tutors to control for the quality and amount of feedback. Note that all participants only took the role of the assessee. Participants were asked to revise their text based on the comments. Support in the SMS condition aimed at helping them to reflect on each feedback comment and to plan corresponding revisions.

Instruments: Current motivation, self-reported and actual feedback uptake, quality of revisions and writing skill were assessed. Actual feedback uptake was assessed by comparing the first draft with the revised text.

Results will contribute to theory building in peer assessment and writing research. Moreover, our findings are expected to help practitioners to effectively support assessees in peer feedback scenarios.

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The added value of scaffolding the self and peer assessment process in a wiki-based CSCL-environment in Higher Education

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Abstract: The present project focuses on how students' learning can be enhanced in CSCL. A growing body of research emphasizes on the added value of assessment for learning in students' learning process. Therefore, the central intervention under study incorporates structure or so-called scaffolds in the assessment process in CSCL. The aim is to study the added value of scaffolding the self and peer assessment process in a wiki-based CSCL environment in first-year Higher Education by focusing on (1) students' perception towards assessment, (2) feedback quality, and (3) product improvement during the assessment process.

Background and goals

CSCL facilitates authentic problems and issues in an educational online environment and it has the potential to foster "new learning experiences that many students have not encountered before" (Fischer, Kollar, Stegmann, & Wecker, 2013, p. 56) – such as collaborative writing and editing of wikis (Cress & Kimmerle, 2008). However, effective collaborative learning cannot be ensured by merely involving students in a CSCL environment (Soller, 2001). In this respect, literature recommends collaboration scripts to scaffold collaborative learning in a certain way to "trigger engagement in social and cognitive activities that would otherwise occur rarely or not all at" (Kobbe, et al., 2007, p. 212). Related to this, previous research highlights learning benefits when structure is provided in a CSCL-environment (Strijbos & Weinberger, 2010), and particularly when structure is offered with the purpose further specifying the roles and activities for the learners involved (Schellens & Valcke, 2006). Therefore, the first two studies examine the added value of providing structure in the peer assessment process in a wiki-based CSCL environment. New approaches of learning and instruction require new assessment practices (Strijbos & Sluijsmans, 2010). A quickly expanding body of literature emphasizes on the educational value of self-assessment (Hattie & Timperly, 2007) and peer assessment (Topping, 2009) to improve the effectiveness and quality of learning. Given that self-assessment is a requirement for effective learning, the development of self-assessment skills is fundamental in higher education (Boud, 1986). Therefore, the third and fourth study will focus on the added value of peer assessment as a scaffolding technique to develop students' self-assessment skills in a CSCL environment. Previous research suggests wikis as an ideal CSCL-tool for supporting assessment activities and online collaboration (De Wever, Van Keer, Schellens, & Valcke, 2011).

Methodology

The different intervention studies adopt a quasi-experimental research design in which students are required to write a draft version, provide feedback and ultimately construct a final version of a writing assignment in a wiki-based CSCL-environment. The participants are first-year bachelor students Educational Sciences (N = 200), enrolled in the course Instructional Sciences at Ghent University. Current status The results of the first study showed that students who use a structured feedback form consider the received peer feedback (PFB) as more profound and detailed, and adopt a stronger critical attitude towards both providing and receiving PFB. Regarding the second study, the focus will be more on the feedback quality and more specifically on measuring the quality of the feedback through content analysis, which is widely used in the CSCL field (Strijbos & Stahl, 2007).

Particular issues to discuss

During the doctoral consortium, I would like to discuss strategies and particular schemes and/or models for analyzing the feedback content. Since previous research highlights deficiencies such as content validity and construct validity, the expertise of the consortium participants on how to employ content analysis would be extremely valuable. Secondly, I would like to "think aloud" with consortium participants on how alternative perspectives and scaffolding strategies could enhance and optimize the assessment process in CSCL. Since I am exactly at the transition phase between my first two studies and the next two, the input from the doctoral consortium could be essential at this particular moment to discuss my research design for study 3 and determine my future direction of the doctoral project.

Math class "unsettled": Teaching and learning mathematics within and across multiple spaces

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Research Goals, Background

The classroom is a space "unsettled," less a static site and more a place-in-the-making or network node (Leander et al., 2010), with new inquiry and instructional methods necessary to understand the work of teaching and learning. Within mathematics education, divergent means, instructional tools, and purposes – from trends favoring practice-focused curricula, to social media practices across contexts (e.g. White et al., 2011), to the sociopolitical turn towards equity and identity – remain contested influences. The Mathematics as Multispacing Project (MMP) investigates curricular and pedagogical designs for pre-service teacher education informed by mathematics practices, place, and participatory culture and digital media (e.g. Jenkins, 2006).

MMP, an initiative within the elementary education program of a large public university in the Midwestern United States, is guided by sociocultural theory and views mathematics education as a context-dependent social practice situated within authentic activities and settings (Brown, Collins, & Duguid, 1989). MMP further assumes that mathematics education depends upon how tools are designed and used to mediate social practices and learning within authentic contexts (e.g. Grossman, Smagorinsky, & Valencia, 1999). This study designed innovative approaches to teaching, and learning to teach, mathematics by investigating how a methods course for pre-service teachers unsettled the classroom-as-container, and how the enactment of course design affected the work of teaching and learning mathematics.

Methodology, Preliminary Findings

This study adopted a qualitative form of case study known as first-person research, an "epistemology of practice that structures and examines the work [of teaching] from the inside" (Ball, 2000, p. 375). Data collection included seven sources of teacher educator design (e.g. lesson plans, teaching journals) and nine sources of pre-service teacher (n=21) learning (e.g. curricular modules, activity structures). 12 micro cycles of design and analysis were completed. Data analysis featured quantitative analysis of descriptive statistics, deductive coding to identify instances of knowledge, practice, community, democratic purposes, and social justice ends (Cochran-Smith & Lytle, 2009), and open coding and analytic induction to address how and in what ways the classroom-as-container was unsettled when teaching and learning to teach mathematics.

Preliminary findings about teacher educator design concern the creation of curricular modules to situate pre-service teacher learning within the authentic activity of multiple geographies and mobilities (e.g. across classroom, campus, community, and online contexts), and the collaborative and iterative design of an online webspace as "nexus" of activity. Preliminary findings about pre-service teachers' learning via classroom activity structures (e.g. assessments, exit slips, lessons) concern conceptions of mathematics knowledge and practice related to place, and the role of formative assessment activities in generating actionable data via online webspaces.

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Social Obstacles to Seeking Help and the Technological Affordances that Alleviate Them

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In order to become a successful self-regulated learner, a student must be able to seek help in an autonomous, and not dependent, manner (Newman, 1994), but we do not yet know what obstacles to help-seeking students face that are particular to CSCL environments. This work aims to answer questions regarding how to leverage affordances of educational technologies to overcome students' social obstacles to seeking help, with a particular emphasis on those social obstacles encompassed by evaluation apprehension and self-presentation concerns.

While Aleven et al (2003) thoroughly reviews how Nelson-Le Gall's (1981) help-seeking process applies to Interactive Learning Environments (ILEs), they explicitly do not explore the same issues in computer-supported collaborative learning (CSCL) environments. Many of the social antecedents to help-seeking may be even more influential in a collaborative learning environment than an individual ILE. Additional literature both within the learning sciences and within social psychology proposes some of these potentially important social antecedents for a help-seeking model. Individual learners have varying sensitivities to evaluation apprehension which might be affected by the helper's perceived status as well as anonymity and publicness of the help request. However, we cannot simply extrapolate findings from help-seeking in the workplace (Bamberger, 2009) to learning settings. These proposed factors that were observed in social and organizational psychology need to be examined specifically in the technology enhanced learning environments being designed.

We propose to examine a small subset of these social obstacles to seeking help in technology enhanced learning environments through a series of studies: (1) Public vs. Private Help in a CSCL environment and (2) the Robot Facilitation Effect. It is possible that offering only public help in CSCL environments prevents students from asking for help, especially those students experiencing excessive evaluation apprehension. An experimental study will be performed with students working in pairs, communicating through a chat window with a whiteboard interface on a learning task with the aid of a conversational agent. The three conditions are: public help-requests only, private help-requests only, and both types of help. In this way, we will be able to examine how students with varying sensitivities to evaluation apprehension will choose to use the help-seeking options with different prevalence levels of evaluation apprehension associated with each help-seeking method.

With the advance of robotics into education (Han et al, 2005) we have a unique opportunity to leverage the physical benefits of robotics with their unique social status. Research points to both children and adults viewing robots as deserving civil rights somewhere between those of an inanimate object and an animal (Kahn et al, 2012), which suggests that evaluation apprehension experienced from the social facilitation of a robot might be somewhere between that experienced in the presence of an inanimate object and an animal. As such, we propose examining how help-seeking is affected by the presence of a robotic helper versus a human helper, as well as perceived social status of the robot. The experimental design consists of four conditions: a "teacher-status" human, a "helper-status" human, a "teacher-status" robot, and a "helper-status" robot.

The use of intelligent tutors and technology enhanced learning environments is often motivated by referring to the cost-effectiveness comparison of the computer tutor and a human tutor. But what if there is an additional benefit? This work explores the potential reduction to evaluation apprehension experienced by the student in technology enhanced learning environments and the best ways to leverage this in tutor design.

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Socio-cultural adaptation of a computer supported collaborative learning environment

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Abstract: the purpose of this dissertation is to examine and to address socio-cultural issues within the CSCL field. To do that, we propose a CSCL adaptation approach based on a conceptual ontology framework. This framework is composed of two ontologies: the first one "SOCUDO" models the socio-cultural user profile; the second one "SCACO" models the socio-cultural aware CSCL domain. These ontologies are closely related; they communicate together to share socio-cultural knowledge about the user such that the instantiation of "SOCUDO" triggers the instantiation of "SCACO" based on socio-cultural reasoning using adaptation rules which link the concept values of the two ontologies.

Motivation

The culture is the most important focus in many disciplines such as anthropology, psychology, sociology, management, education, to cite but a few. Its impacts have been highlighted on many human characteristics and activities such as human behaviors, communication, learning, cognition, personality, emotion and motivation. Regarding this strong relation between culture and human beings, socio-cultural issues were addressed in computer science systems in different ways: adaptive user interfaces, personalized information retrieval processes, enhancing language learning. However within CSCL field, there are few practical researches in that matter. In fact, in intercultural collaborative learning settings, we need to get and ensure better interaction, to get better learning. Better interaction is reached by promoting motivation to learn in groups and this is obtained by enhancing user satisfaction which is got by the development of tailored CSCL tools to each user according to his socio-cultural background. This context start-up a challenge: How to consider socio-cultural specificities of each learner? To address this challenge, we introduce an ontology based approach for the socio-cultural adaptation of CSCL environments where a socio-cultural profile is defined to provide dynamic adaptation. The proposed approach spans a variety of research fields ranging from cultural anthropology to user modeling and adaptive CSCL environments. So, there are many research questions arising from these fields: questions about what socio-cultural knowledge to be modeled and how; questions about how CSCL system will be socio-culturally adapted and when and what are the CSCL components we should adapt and questions about the benefits of socio-cultural adaptation of the CSCL systems.

Main contributions

We propose a conceptual ontology framework composed of two ontologies: the first one called SOCUDO models user socio-cultural characteristics; the second one called SCACO represents the main collaborative learning concepts socio-culturally sensitive. The concepts and relations of SOCUDO (Ouamani et al., 2011; Ouamani et al., 2012) were brought from research studies that show the socio-cultural impacts on individuals while those of SCACO were brought from research studies that highlight the cultural influences on learning and collaborative learning. The two ontologies communicate to share socio-cultural knowledge about the user in order to trigger the appropriate adaptation tasks. The SOCUDO ontology is instantiated for one user after his/her information inputs via the forms; if the user is influenced by more than one culture, the cultural concept values will be calculated using a proposed algorithm that we called "acculturation algorithm" and Hofstede (1980) scores; this instance of SOCUDO triggers an instance of SCACO for this user based on adaptation rules. Then, the adaptation process will use this instance to trigger the right adaptations tasks for this user.

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Student-Student Debates during *Scientific Cafés* on Drinking Water: Group Dynamics, "Spontaneous" Argumentative Skills, and the Argumentative Use of Emotions.

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Goals of the Research

The goal is to better understand students' "spontaneous" argumentative practices while debating on a socio-scientific issue (SSI) and their contextual variation. We aim at a detailed description of the argumentative skills, collaboration features and content resources that the students use, without previous teaching on argumentation.

Background of the project

Since 2007, members of the ICAR lab have been working on the transfer of *scientific-café*s into the classroom. Support from the *Région Rhône-Alpes* enabled us to design a new script, which was applied in 2011-1012 in 4 schools in France (Lyon), the US (Kenosha, Wisconsin) and Mexico (Contepec, Michoacán; Tehuacán, Puebla). Both argumentation (e.g. Andriessen, Baker & Suthers, 2003) and SSI (e.g. Kolsto, 2001) are claimed necessary to science and citizenship education, but little is known about the way the students debate on SSI. A better understanding of their practices and their variation can help design future pedagogical activities on SSI.

Methodology

The *scientific café* macro-script was co-designed with the *Association Rhône-Alpes des Petits Débrouillards*, specialized in non-formal science education. Seventeen *cafés* were organized and fully videotaped. The key last final debate on the "main question", was systematically transcribed and analyzed for 10 events. For 6 of them, I also worked on the other debating activities of the script.

My methodological approach is based on 5 key choices: 1) to be radically descriptive: understanding how the students manage to argue, rather than evaluating their arguments; 2) to switch from one level of analysis to another; 3) to treat emotions as a dimension of the "schématisation" process (Grize, 1997) and not as an external factors affecting the argumentation process; 4) to pay attention to the contextual differences that may appear during the analysis without formulating any prior hypothesis neither on the nature nor on the level of variation.

Preliminary results

The principles defined by Plantin (2011) are efficient to characterize the emotional positions that the students use as argumentative resources. In different places, some students have similar emotional positions when they defend the same argumentative conclusion, whereas some students of the same classroom display a very different emotional position if they don't agree.

A slightly refined version of Mercer's typology of exploratory, disputational and cumulative talks (1996) let understand some of the variations observed in the collective argumentation process among the small groups. It seems that there is a cultural variation on the way the students get into "exploratory" talk. But other contextual factors are at work at a microscopic level when it comes to understand why some groups do not engage in exploratory talk. They tend to cumulative talk when they are more concerned by their relations than by the issue discussed, and to disputational talk when they feel offended.

The content resources used by the students go from beliefs to knowledge, and can be classified into "fundamental norms" (moral values), "procedural norms" (rules of the debate), and "regularity-norms", (causal phenomenon presented as facts). None of these norms seems exclusively related to a specific national culture.

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Designing an Interactive Exhibit for Exploring Complex Data in Informal Learning Environments

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Introduction and Background

My research seeks to further our understanding of the collaborative learning that occurs in informal, social environments around large, complex data sets through the design of an interactive exhibit. I am investigating the narrative elements (Wertsch, 1998) produced by visitors around a geographic information systems (GIS) map display and how users' manipulation of the data through embodied interaction affects these narratives. Our display, CoCensus, tracks visitors as they explore and "play" with ancestry data from the U.S. census. We seek to get visitors asking questions, sharing hypotheses, and building off each other's hypotheses to contribute to a collaborative learning experience. I focus on visitors' integration of the data with their own knowledge and experiences.

Methodology

We are undertaking design research (Edelson, 2002), operating with the twin goals of understanding the way embodied interaction impacts social learning within a museum space and developing an interactive display that supports this learning. The design has already progressed through several iterations, tested *in situ* in the Jane Addams Hull House museum. Museum visitors were invited to participate in semi-structured interviews, which were recorded using screen and audio recording software (Pilot study) and video camera and microphones (Phase II).

Preliminary Findings

Pilot testing was conducted in the spring of 2011 (Roberts, Radinsky, Lyons, & Cafaro, 2012). In this initial prototype visitors produced narrative elements (Wertsch, 1998), but visitors did not demonstrate as much personal connection to the data set as we hoped. We hypothesized that adding the interactive element of the display would augment this interaction, and that this connection would deepen the experience. Therefore the second study tested an interactive version of the display (Roberts, Cafaro, Kang, Vogt, Lyons, & Radinsky, 2013). Ongoing analysis explores the visitors' movements within the interaction area during the interviews to study *how* visitors utilize the embodied interaction and at what interaction level they are operating (Williams, Kabisch, & Dourish, 2005). Pairing users' physical movements with their speech can give insight to the way they are using movement to make sense of what they're seeing, which can inform both the learning theory and future design iterations.

Ongoing Issues and Challenges

Through these studies I intend to examine the learning occurring around these displays while improving the design of the display itself. Open questions for my research include: What are the meaningful manipulations of data that can lead to personal connections? What movements and gestures intuitively trigger these manipulations to help users get to William et al.'s 4^{th} level of interaction? How do we help people co-construct their narratives? Where is the balance between too little data to be engaging and too much data to be manageable?

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Promoting Andean children's learning of science through cultural and digital tools

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Abstract: In Peru, there is a large achievement gap in rural schools. In order to overcome this problem, the study aims to design environments that enhance science learning through the integration of ICT with cultural artifacts, respecting the Andean culture and empower rural children to pursue lifelong learning. This investigation employs the Cultural-Historical Activity Theory (CHAT) framework, and the Design-Based Research (DBR) methodology using an iterative process of design, implementation and evaluation of the innovative practice.

Introduction

Peruvian rural schools are attended by indigenous children belonging to Andean communities that have an ancestral culture and different perspective of the world (Huanacuni, 2010). In the last decade, results of national tests have shown a rural educational achievement gap. In order to overcome this problem, the government has created different projects. One of them, implemented since 2008, was the use of Information and Communication Technologies (ICT) in rural schools to provide a more equitable quality education. Therefore, it is desirable for this study to find out the better approaches to solve this problem and provide a tentative solution.

The aim of the study is to design environments with the co-participation of the stakeholders to enhance science learning through the integration of new technologies, respecting local viewpoints of the world, and empowering rural children in the Peruvian Andes to pursue lifelong learning.

Theoretical framework and methodology

The best way for exploring the learning process that leads children to obtain agency and empowerment is to co-design the activities respecting the local culture employing the CHAT framework (Engeström, 1987) and using the Design-Based Research (DBR) based on iterative interventions in a real-world context. The research is carried out in an Andean community (Puno-Peru), employing a purposeful sampling, and designing a space for exploring, based on guiding principles (Brown & Campione, 1994). The participants are: volunteer children (6-11 years old), teachers and the principal from the rural school, parents and elders from the village community, and one representative of the Ministry of Education.

Proposed Intervention

The study is a kind of afterschool intervention. It will last from March to December 2013, through an iterative process of three successive sub-interventions, in each of the school terms. *Pre-intervention*: In this stage, it is established the initial conditions and contextual information (baseline). *Intervention*: It consists of three iterations or sub-interventions: 1) First Iteration: It will be conducted a meeting with the stakeholders to co-design and co-planning an environment that integrates the Andean culture. There will be about 12-16 learning sessions to carry out the projects. Then, the children will present their findings in a community meeting, explaining what they have learned. 2) Second Iteration: In this iteration the facilitator will start to withdraw slowly and help children to become more confident for making their own decisions. 3) Third Iteration: During this iteration the children might plan their projects more independently, monitoring their own learning processes, and practicing their empowerment. *Post-intervention*: In this stage, it will be carried out the last meeting with all the stakeholders to evaluate the whole intervention.

In general, it will be used mostly qualitative methods: interviews, observation, documents and so on to develop a thick description of the process that will lead to a deep understanding.

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Supporting Collaborative Multimedia Learning – The Effects of Presenting Knowledge-Related Partner Information

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Abstract: Collaborative multimedia learning, as a complex and demanding scenario, can be supported by providing cognitive group awareness information. My Ph.D. project comprises a series of three studies to isolate and investigate the effectiveness of three specific components which are typically intermingled within cognitive group awareness tools. Results of the first study indicate that information cueing, i.e. emphasizing relevant aspects of the learning material constrains communication space to reduce complexity, which is an encouraging starting point with respect to the forthcoming studies.

Background

Collaborative multimedia learning raises many challenges as learning partners have to (1) establish references between external content and communication, (2) construct a common ground and mentally integrate their partner's knowledge, (3) structure their communication and interaction in a goal-oriented way, and to manage all these tasks simultaneously in the realms of their limited working memories. My doctoral thesis focuses on supporting cognitive group awareness as an implicit approach to scaffold learners to overcome these different challenges (Janssen & Bodemer, 2013) and is embedded in a research project funded by the German Research Foundation. The effectiveness of cognitive group awareness tools has already been proven in studies for collaborative learning with different multimedia material. However, those tools typically combine three components, as they (1) emphasize relevant aspects of the learning material, (2) present knowledge-related partner information, and (3) enable a comparison between own and partner information (Bodemer, 2011). Hence, this project comprises a series of three studies, each designed to experimentally isolate and investigate the potential of one of those components and to clarify their effectiveness in cognitive group awareness tools.

Experimental Scenario

All three studies are based on an identical experimental design: During a first collaboration phase learners are provided with multiple external representations, i.e. material that contains formulas and a static visualization. During another subsequent collaboration phase the visualization is augmented by several dynamic and interactive components. In addition, during each collaboration phase learners are either provided with one of the aforementioned components of a cognitive group awareness tool or not. Thereby, collaborative processes like communication, learning interaction and collaboration load as well as individual states and outcome like cognitive load and learning gain are measured and analysed.

First Study

The first study was conducted to examine the effectiveness of information cueing, i.e. emphasizing relevant aspects of the learning material. Accordingly, essential information were cued by visually highlighting relevant components in terms of color during the first collaboration, and by providing essential causal relations between variables during the second collaboration. Both collaboration phases were conducted using a multi-touch table, enabling face-to-face communication between learning partners. A total of 172 university students participated (109 females and 73 males), aged 19-31 years ($M = 22.93$, $SD = 2.48$), were paired into dyads and randomly assigned to four experimental groups. Overall, results of this first study demonstrate that emphasizing relevant aspects of the learning material is an effective component of cognitive group awareness tools which seems to constrain communication space to reduce complexity. This is a promising milestone of my Ph.D. project to fully understand and explain the effects of cognitive group awareness tools. For a comprehensive description of the experiment and its results see Scholvien and Bodemer (in press).

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Supporting facilitation for informal learning with mobile technology

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Abstract: Interpreters in informal learning spaces need to effectively reach many visitors when facilitating digital, performative exhibits. My research concerns how interpreters can be supported in dynamically distributing facilitation and attention across multiple modes of visitor participation. My preliminary approach and results are summarized below.

Introduction

Currently, Informal Science Institutions (ISIs) such as museums and zoos are designing exhibits incorporating hands-on interaction with dynamic digital content. Educational interpreters in ISIs are highly effective at improving visitor learning with traditional exhibits, but it's unclear how to incorporate their facilitation most effectively into new exhibits driven by individual visitor performance. This indicates that there is need for a new approach to the interpreter's role in the informal learning experience. My goal is to investigate how to design technological supports for interpreters, such that they can dynamically distribute their facilitation and attention to orchestrate visitor learning across multiple modes of visitor participation.

Interpreters can be equipped and trained with adaptive tools that allow them to responsively alter exhibit content, highlight additional media, and engage in "just-in-time" mediation of visitor learning. This allows interpreters to engage both the central participants in performative exhibits, as well as more disengaged peripheral audiences. Reaching both of these audiences is a unique challenge for informal learning spaces.

The testbed for my research is the prototype exhibit, "*A Mile in My Paws*" (*Paws*), an interactive climate change game. This exhibit relies on a single visitor who generates information about polar bears' responses to climate change through their performance. The "lesson" is clear to the performer, but it's unclear how to support the simultaneous learning of a wider audience at this exhibit (Jimenez Pazmino et al., 2013).

Current status and preliminary results

For interpreters to successfully engage multiple forms of visitor participation in performative exhibits, they need to move beyond typical rote delivery approaches, which can't account for dynamic visitor-generated content. However, providing adaptive, relevant facilitation to large groups of visitors is a difficult task, as performative exhibits require interpreters to emphasize change over time, link immediate and distal events, and explain complicated multi-level phenomena. Interpreters learning to perform these tasks require scaffolding, which can take the form of a mobile, digital support tool. This tool would aid them in distributing their facilitation and attention to address multiple groups of visitors, who are participating in different ways in a single exhibit.

I am following a design research methodology that involves iterative improvement of technological supports, interpreter training, and exhibit design, with the participation of the zoo interpreters themselves. To date, the *Paws* team has performed three pilot studies, with the third pilot being the first to evaluate the success of *Paws* "on the floor" of the zoo (Slattery et al., 2013). This two-day pilot involved 12 interpreters interacting with visitors across 26 play sessions, in which hundreds of visitors came into contact (many brief, but some extended) with *Paws*. From this pilot, I began by investigating one interpreter's extended interaction with a visitor family group across three play sessions. His approach to visitor interaction was relatively unchanging, but he did move beyond rote facilitation based in his authority as interpreter, and included data displays on the *Paws* support tool as a source of visitor learning. Nonetheless, his interaction with the family group drew on the *Paws* player experience in a limited way, indicating that interpreters still need support in linking visitor-generated exhibit content to peripheral visitor audiences.

My current next steps are towards supporting responsive and extended interpreter questioning, improving interpreters' epistemological positioning of exhibit resources, and better integrating visitor-generated content into interpreters' mediation of the *Paws* exhibit. Investigating these interpreter practices will then allow me to focus on how to extend them across multiple forms of visitor participation, and how best to scaffold more responsive ("just-in-time") facilitation with digital support tools.

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Scripting and orchestration in smart classrooms

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Abstract: This project involved the development of a 13-week inquiry curriculum for high school physics where students engaged in scientific discourse and knowledge construction around peer-contributed artifacts. The culminating smart classroom activity involved the real-time orchestration of students solving ill-structured physics problems using Hollywood film as the inquiry domain. A focus of this research is the investigation of orchestrational supports for smart classrooms including ambient displays, locational dependencies, and intelligent software agents that respond to emergent class patterns.

An Increasing Complexity of Designs in CSCL and Orchestrational Supports

As CSCL interventions are becoming increasingly complex in terms of the interactions, roles, goals, and real-time supports we require there is a growing need to structure these elements in the form of pedagogical scripts. There is a parallel need to provide teachers and students tools to help orchestrate their enactment. In response we developed SAIL Smart Space (S3) and open source framework to support the scripting and orchestration of activities within a smart classroom context. This work research serves as a reference implementation of an S3 supported smart classroom activity. Below I describe the designed curriculum and its enactment.

Research Design and Questions

My research investigated the use of S3 in a 13-week high school physics curriculum that spanned multiple contexts (at home, on "the street", in the classroom, and in the smart classroom). In particular my research questions aimed to answer the following questions: How can students be supported in the development of a knowledge community across multiple learning contexts (at home, in their neighborhood, in class, in a smart classroom)? How can we support a smart classroom learning environment and the orchestration of activities within such an environment? What kinds of interaction patterns do these kinds of environments support, and what new interaction patterns emerge during their enactment?

Methods

We co-designed a 13-week high school physics curriculum for two sections of an 11th grade physics class. The intervention produced a complex CSCL script, interweaving activities where students (1) captured examples of physics phenomena in the world around them using mobile phone cameras, (2) tagged, explained, and uploaded them to an online community space, (3) completed regular homework tasks, (4) created "challenge problems" based on their previously created work (see Figure 1). The products of these interactions became a resource for in-class and at-home activities, including debate and peer feedback - all focused around the 12 core physics principles, serving as a design framework for the course (using the KCI model). The curriculum culminated in a one-week activity where students solved ill-structured physics problems based on excerpts from Hollywood films and consisted of three phases: (1) <u>at home solving and tagging</u> of physics problems; (2) <u>in-class sorting and consensus</u>; and (3) <u>smart classroom activity</u>. The smart classroom activity is described in detail below.

For the smart classroom activity, each class was broken up into two separate intervention groups (class 1, n_1=10, n_2=9; class 2, n_3=12, n_4=8). In the smart classroom, students were heavily scripted and scaffolded to solve a series of ill-structured physics problems using Hollywood movie clips as the domain for their investigations (i.e., could IronMan Survive a shown fall). Four videos were presented to the students, with the room physically mapped into quadrants (one for each video). The activity was broken up into four different steps (Figure 3): (1) Principle Tagging; (2) Principle Negotiation and Problem Assignment; (3) Equation Assignment, and Assumption and Variable Development; and (4) Solving and Recording. In each step students moved, or were sorted, within the room completing a set of collective and collaborative tasks that built upon the emerging knowledge base, using their tablets or large format interactive displays. During the activity the teacher used a set of specially designed feedback technologies (described below) to aid in its orchestration.

Current State of Research

As part of my PhD research I have begun investigating several facets of the intervention. I am currently examining the smart classroom run to evaluate the effectiveness of the orchestrational supports with a focus on: **Ambient Feedback**, through the use of a large ambient display; **Scaffolded Inquiry Tools and Materials**, such as the interactive large format displays and tablet apps; **Real-Time Data Mining and Intelligent Agency**, as performed by the S3 software agents; **Locational and Physical Dependencies**, which include how successfully inquiry objects were mapped to the physical space of the room; and **Teacher Orchestration,** which includes s specially designed teacher tablet and examinations of how the teacher used the large format displays for his own decision making.

Supporting students' historical reasoning through a collaboration script.

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Abstract: The main goal of the research project is to examine the impact of a computer-supported collaboration script on students' approach to a historical inquiry activity. A first study was recently conducted and a second study is now being designed. This contribution mainly focusses on the theoretical framework of the research and important design issues, such as the risk of over-scripting.

Background and methodology

Research on history learning has consistently emphasized that students should not only gain insight into the past, but must also acquire a basic understanding about the methods historians use to study the past, and be able to use these in historical inquiry activities. However, historical inquiry is a complex process and often presents difficulties for students (Van Drie & Van Boxtel, 2008). CSCL seems a promising approach to support students when conducting such inquiry activities. Computer-supported collaboration scripts in particular, seem well suited for this purpose, as they can specify and sequence activities and roles to guide students through the inquiry process (Kollar, Fischer, & Slotta, 2007).

The focus of the research lies on two groups of students: 4th graders studying history in secondary education (normally aged between 15 and 16, cf. international 10th grade), and pre-service history teachers following a training to teach in secondary education, up to the 4th grade. Student dyads use a computer to collaborate on a historical inquiry activity and are guided through this task by a collaboration script. Using a design-based research approach (Brown, 1992), the goal is to construct a script that can support (1) use of sources, which consists of interpreting, evaluating and comparing evidence, and (2) construction of arguments, which involves defending a claim about the past, by supporting it with evidence and weighing different arguments against each other (Van Drie & Van Boxtel, 2008).

Current status and issues

At the time of writing, a first study has been conducted in history teacher education. In a 4-hour long activity, students collaborated on a historical inquiry activity, which required them to review several pieces of evidence and construct an argumentative text. 16 student dyads were randomly divided over a control and experimental condition. Both conditions received a script guiding them through the task, but the experimental condition's script also prompted students to form arguments related to the problem after reviewing each source. A first look at the data suggests that the script had no significant impact on students' domain-specific knowledge ($U = 200.5$, $p = 0.22$). Students' interaction and final product have yet to be analyzed, although their responses during focus groups following the intervention indicated that the script influenced their approach of the task.

Considering the design of the first study, it seems likely that a more densely structured script or a more active involvement of the teacher to support students' thinking is better suited for producing the desired effect. However, this also increases the risk of over-scripting students' behavior, which impedes a thoughtful approach of the script (Dillenbourg et al., 2009). Unfortunately, the available literature offers little concrete advice on how such over-scripting can be avoided. It is also largely unclear which approaches are helpful, and which conditions are essential in order to develop a script that can stimulate students to internalize domain-specific standards for historical inquiry. The session will therefore focus on a presentation of the theoretical framework of the research, in order to stimulate a discussion of these themes.

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Collaboration Skills across Various Domains: Effects of CSCL Scripts on Learning Processes and Outcomes

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Abstract: This work includes two different approaches to analyze the effectiveness of CSCL scripts. In study 1, a meta-analysis was conducted that investigated the question which effects CSCL scripts have on learning and which specific script features might moderate these effects. In study 2, an experimental intervention study tackled the question to what extend a specific CSCL script has an impact on students' acquisition of argumentation skills when learning collaboratively in the domain of mathematical proof.

Goals and Background

CSCL scripts aim at a facilitation of domain-specific knowledge as well as at learner's internalization of educationally meaningful strategies. Using the Script Theory of Guidance (Fischer, Kollar, Stegmann, & Wecker, 2013) as theoretical framework, this project is driven by the question which general CSCL script features influence the collaborative learning process and which collaborative learning activities (Chi, 2009) induced by CSCL scripts lead to better learning than unstructured CSCL. The large amount of research on CSCL scripts over the past years with diverging suggestions about the effects of CSCL scripts motivated a statistical meta-analysis in study 1. Although argumentation is a meaningful educational strategy in the context of mathematical proof, research about CSCL scripts supporting argumentation is rare in this specific context. Thus, study 2 looks at the effects of a CSCL script that is designed to scaffold students' acquisition of mathematical argumentation skills. To investigate the impact of an additional domain-specific support for the effectiveness of CSCL scripts, heuristic worked examples are also implemented in the learning setting.

Methodology

Study 1 addresses the general questions about the beneficial features (e.g. providing additional domain-specific support) of CSCL scripts by using a meta-analytical approach. N = 19 comparisons of conditions with CSCL scripts against control conditions were analyzed for their effects on learning outcomes. Study 2 investigates the effectiveness of CSCL scripts in the context of mathematical proof and the role of additionally provided heuristic worked examples as domain-specific support in an experiment with N = 101 university students.

Preliminary results

The meta-analysis (study 1) revealed that learning with CSCL scripts compared to unstructured CSCL had significant positive overall effects on students' domain specific ($d = 0.36$, $p < .01$) and domain-general learning outcomes ($d = 1.07$, $p < .01$) with moderate to large heterogeneity. Further, additionally provided domain-specific support positively affected the effectiveness of CSCL scripts on domain-specific outcomes ($d_{\text{Diff}} = 0.47$, $Z_{\text{Diff}} = 2.01$, $p < .01$). A 2x2-factorial ANOVA (study 2) revealed positive effects of the CSCL script and the heuristic worked examples on the use of collaborative learning strategies. Sobel tests showed that, compared to other learning activities, transactive argumentation significantly mediated the effect of the collaboration script ($Z = 2.26$, $p = .01$) and the heuristic worked examples ($Z = 2.32$, $p = .01$) on students' knowledge acquisition.

Issues to be discussed

Although the meta-analysis detected positive effects of learning with CSCL scripts the amount of heterogeneity also reveals that further investigation will focus on detailed analyses of moderators that could be derived from the principles stated in the Script Theory of Guidance (Fischer, et al., 2013). The experimental study underpinned that it is important for beneficial CSCL scripts to induce transactive activities (Noroozi, Teasley, Biemans, Weinberger, & Mulder, 2013). To shed light on how learner's mutually influence each other in their activities, the collaborative learning process and its sequential structure will be analyzed in more detail.

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Web 2.0 Tools to Support Science Practices: High School Students Engaging in Argumentation

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Abstract: Sociocultural learning theory is used to study how students use Web 2.0 tools to support their participation in the science practice of argumentation. I analyze video data and data from social bookmarking, wiki, and podcasts from learners (n=34) as they participated in a unit on alternative energy in a high school chemistry class. Initial findings suggest that students improved understanding of the content, appropriated practices of argumentation, and considered the role of audience in argument construction.

Dissertation Research Goals

I examine how student participation in science practices of argumentation (Newton, Driver, & Osborne, 1999) is supported by Web 2.0 technologies a high school science unit on alternative energies, specifically how social bookmarking and tagging, wiki, and podcasting can be used to support the goals of argumentation (Berland & Reiser, 2009). The focus was to provide resources students could use to facilitate the necessary communication and collaboration (Bruckman, 2006) as they engage in argumentation. Two classrooms (n = 34) were observed over a 3-week period. Data collected included: group video-podcasts, social bookmarking data, wiki records, student questionnaires, small group interviews, and video-recordings. I answer three research questions: (1) How do students use tagging to support their individual sense-making? (2) How does group authoring online publications support student communicating their understandings? And (3) How do students use multimedia technologies to support argumentation?

Theoretical Framework and Methodology

My dissertation uses sociocultural learning theory where culture and cultural tools mediate learning (Vygotsky, 1978) in its research design. I take learning as a socially constructed process where students learn as they participate in practices. This participation is mediated through the use of tools and artifacts. The video-recordings were analyzed through development of content logs (Jordan & Henderson, 1995) to identify critical events and examined using an interpretative analytical approach.

Preliminary Results and Next Steps

I analyzed the social bookmarking accounts, wiki pages, podcasts, and video records, and students' end-of-unit reflections. The podcasts were analyzed using an argumentation framework modified from Zohar and Nemet (2002). Initial findings indicate that students appropriated the structure of argumentative discourse. Students stated that designing the podcast forced them to engage more deeply with the content and had an impact on their argument design.

In this consortium, I will focus on the analysis of segments of student discourse on videotape records and the artifacts that were constructed, as well as the collaboration that occurred within and across two separate classrooms during creation of the wiki. Impacts on future research would be discussion about the use of collaborative tools for supporting practices and learning, as well as analysis of the same.

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Habits & Habitats: Ethnography of a school based learning ecology

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Abstract: Within the field of CSCL, observation customarily follows the design and, or implementation of a new tool, script or digital learning environment. This study sets out to describe a collaborative learning environment with high reliance on ICT's that exists "in the wild". A total of 549 hours of observation will be used to process theories of: materiality, practice and orchestration, in an examination of the relationships between learning activity and the learning environment.

How do materials participate in the everyday practice of learning? What is the role of spatiality in the performance of practice, and how do notions of time intersect with and give rise to the conditions from which convivial learning communities emerge?

Despite an underlying assumption that, at least on some level, our environments influence what we do, a review of the literature on formal education reveals that empirical research on relations between the physical environment and learning is surprisingly sparse, and where connections have been documented they are, more often than not, between environmental factors and students' *wellbeing*, rather than their *learning* (Boys, 2011; Woolner, Hall, Higgins, McCaughey, & Wall, 2007). Where research has focused on the relationship between technology rich environments (Brooks, 2011) or individual elements of the built environment (Barrett, Zhang, Moffat, & Kobbacy, 2013) and on *learning* - positive results have been demonstrated; however, the attribution of these improvements remains a challenging task. As such the aim of this research is not to work towards a single theoretical summation, but to illuminate the complexity of relations between people places and tools – in a rather unusual learning environment.

NBCS is an independent K – 12 school on the outskirts of Sydney, Australia, and it is shaped by a culture of research-based practice amongst its staff. Seven years ago, they set about reshaping their curriculum to accommodate collaboration and differentiation using computing technologies. Having established a new framework the staff vocalised a tension between the new way of teaching and the built environment, which they described as "working against" their best efforts to effect change. A second phase of redevelopment sought to remedy this and it was in one of these new environments, the Zone, that observations for this study took place.

The Zone is home to 180 year five and six students and their team of seven teachers and it had been in operation for two years by the time observations for this study commenced. A total of 549 hours were spent with this cohort over nine months, focusing their use of tools and space, the ways in which they co-configured their environment, and the subtle impact of an altered apportioning of time within the traditional school week.

Analysis is informed by Estrid Sørensen's (2009) minimal methodology in which she makes a case for researchers to use empirical material to process theory. Consideration has been given to theories of materiality (Ingold, 2011; Shove, Watson, Hand, & Ingram, 2007; Sørensen, 2009), the relationship between space and its occupation (Boys, 2011; Goodyear, 2000; Ingold, 2011), and the processes whereby the requirements of interactive teaching and classroom management are given thorough consideration in the process of instructional design (Dillenbourg, Dimitriadis, Nussbaum, Prieto, Asensio, Sharples, & Fischer, 2012).

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Volume 2

Early Career Workshop Papers

The CSCL 2013 Early Career Workshop

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Summary

The *Early-Career Workshop* is an opportunity for researchers working in CSCL and in the Learning Sciences early in their careers to discuss their own research, to discuss post-doc and early-career challenges with peers and senior mentors and to initiate international networks related to their research topics. The early career workshop is designed for post-doc and early career researchers starting with those who have just finalized their doctoral thesis to those having 5 years of experience after receiving the doctorate with research interests in CSCL and the Learning Sciences. The cohort this year comes from the United States, Europe, Asia and Australia.

Two primary goals underpin the organization and selection of activities for the Early Career workshop:

- Fostering community building (a) among the cohort of early career researchers, and (b) between early career researchers and senior researchers in order to develop academic, professional, and personal support networks, and

- Deepening participants' understandings of the elements of successful academic and professional development, including the building of a research program, requirements for tenure and other professional benchmarks, pointers for grant proposal and journal writing, mentoring graduate students, preparation for multidisciplinary and multi-cultural collaborations, and negotiating a balance among institutional service, academic writing, and teaching.

This year we have chosen a special theme of mentoring through non-traditional career paths. While we will continue to offer all of the support and advice to those in our community who are taking steps along a traditional, tenure track career path, we will also address issues that are specific to those who have made other choices for a variety of reasons.

During the workshop (1.5 days) itself, participants will present their research and get feedback, talk to different mentors in small groups and discuss possible new international research networks with their peers. In addition, a "meeting with the journal editors" session will be organized. Main contents of the workshop are: Research funding opportunities for post-docs and early career researchers; how to develop a research agenda, and/or consider their own career development, publishing, where and how much, promotion; how to mentor and supervise graduate students; new research methods; possibilities for building international research networks; international mobility/going abroad: How, how long, where to? The workshop will also have a focus on the specifics of the CSCL community and on the challenges with which this community is confronted (interdisciplinarity, gaps between different methodological approaches).

Betsy DiSalvo: Summary of Research

Abstract: In my research I use cultural values as lens to understand everyday technology practices and their implication on learning. Using ethnographic and design research methods I conduct in-depth formative work and create interventions to better understand motivations to learn and motivations to actively not learn. My work focuses on disadvantaged and underrepresented youth who are frequently difficult to reach with traditional learning. Digital media and technology offer unique opportunities to leverage identity and computation to encourage learning within these groups.

Introduction

Using *situated learning* (Lave and Wenger 1991) as a lens for understanding children's and young adults' out of school learning environments I explore how *cultural values* (Schwartz 1999) shape access and acceptance of technology learning. If technology is constructed by social and cultural influences (Bijker 1995) we need to examine who is given the access and ability to produce new technology. The lack of diversity in computational production serves as a discipline specific example. With computing, situated practices around using and learning computers impact both who is producing new technologies and the types of technologies being produced. I strive to create both opportunities for equitable employment among marginalized groups such as African Americans, Latino/as, and women, and bring the values and perspectives of groups that are marginalized into the design and production of more inclusive technologies. Using a mixed methods approach to my work enables me to develop research agendas that blend the needs of communities with research questions that will serve the learning sciences and human-centered computing fields. Formative work is conducted with qualitative interviews and observation and design research methods from the fields of design (Nieusma 2004, Ehn 2008) and learning sciences (Barab and Squire 2004). Quantitative work is used as a supplement to formative findings, evaluation of the effectiveness, and as additional lens of analysis of qualitative findings.

Background

In my previous work at the University of Pittsburgh Learning Research and Development Center with Dr. Kevin Crowley I led the development of the Click! Urban Adventure Game (DiSalvo, Parikh et al. 2006, Hughes 2007). This work was informed by Dr. Crowley's work with informal learning and *islands of expertise* (Crowley and Jacobs 2002) and initiated my research into leveraging children's passions for games into learning opportunities.

As a graduate student at Georgia Tech, I worked with Dr. Amy Bruckman to find ways to leverage young African American males' digital game play into an interest in computing. Using design research methods, young African American males and I co-designed the Glitch Game Testers (DiSalvo, Guzdial et al. 2013). In this program African American male high school students worked full-time in the summer and part-time in the school year, testing pre-released games for real companies. They were paid for their work and one hour each day was spent in computer science workshops. We opened in 2009 and our success rates for engagement with computer science are remarkable. Of the 25 students who have graduated from high school, 21 went on to college or trade school, with 16 as computer science or digital media majors. Glitch offered three levels of research: formative work on cultural and social technical practices, design research on the development and iterations of a learning intervention, and a research environment for theoretical work on motivation to learn (DiSalvo, Bruckman et al. in press).

Current Research

Currently, I am launching two initiatives to explore the broad ecology around technology and learning. These initiatives are the Parent STEM Portals and the Computer Service Youth Cooperative.

Parent STEM Portals

The Parent STEM Portal program is set of studies to first, gather and analyze data on parents' use of digital media for informal learning, and then to conduct design research, creating prototype portals to facilitate access to Science Technology Engineering and Math (STEM) learning. Recently, there has been an explosion of educational courses and informal learning tools and activities offered online. While these learning resources are frequently free and flexible, there is a question if these free educational resources actually widen the digital divide (Reich, Murnane et al. 2012) because of issues of access. In a study of parents acting as learning partners in the development of technological fluency, Barron and colleagues (2009) found that parents can play a critical role in creating learning opportunities for their children. Two parenting roles identified in the study, *Learning Broker*, when parents seek learning opportunities for the child; and *Resource Provider*, when parents supply resources to the child beyond the family computer, are tied to the parent's ability to effectively seek online resources and information.

These research finding highlights the need to address differential access and presentation of online learning. Digital *access* goes beyond who can find a network connection. We consider what people do and what they are able to do online. DiMaggio et al. (2004) suggests that digital access can be explored through five aspects; (1) means to hardware, software and the internet, (2) autonomy of use, (3) skill to use and troubleshoot, (4) social support to get help and encouragement, (5) purpose for using technology. Variations in the presentation of informal learning experiences have demonstrated that parents will select learning opportunities that they feel are culturally and gender appropriate for their children. For example, in work with the Power Girl exhibit at the Children's Discovery Museum in San Jose researchers initially observed that girls were choosing to go to an exhibit on electricity, but their parents were steering them away. After the exhibit added the character Elena, or "Power Girl", parents began engaging girls at equal rates as boys with the exhibit (Lobel and Crowley 2001). This raises the question of how cultural indicators attached to online tools and websites can shape parents selection of informal STEM learning opportunities.

To explore these issues of technology access to and presentation of informal learning we have begun conducting initial interviews and surveys with parents. We are focusing on four groups: low-income African American families, Latino families, parents participating in technology outreach programs, parents of deaf children. Based upon these initial studies and using participatory design practices we will design and develop Parent STEM Portal prototypes. The goal is to create a framework that can then be customized according to communities' needs and values. By understanding and designing for parents technology use and cultural values we can increase access to the rich array of free and inexpensive informal STEM learning among young people who are often overlooked.

Tech Support Youth Co-operative (TSY Co-op)

The CSY Co-op seeks to leverage the importance of paid work among African American high school students that we observed in the Glitch Game Testers program. However, Glitch has been difficult to grow into self-sustaining company and a lacks a community connection. With the CSY Co-op we are seeking to establish a sustainable business model that actively serves the community and offers ongoing computer science (CS) education program. We observed in Glitch that participants enjoyed building and refurbishing computers. Using that interest, we will be co-designing with high school students a co-operative in The Bluffs neighborhoods of Atlanta. We anticipate similar outcomes to the Glitch program including increasing interest in studying CS among African American students. We also see TSY Co-op as an opportunity to expand on open research questions regarding learning motivations and sustaining interest in the face of adversity and cultural conflict.

The Bluffs are a collection of low-income African American neighborhoods that have faced significant displacement and access issues due to development of Georgia Tech and the 1996 Olympics. The resulting physical and social infrastructure in these neighborhoods has contributed to create one of the most impoverished educational landscapes in the U.S. Research initiatives in the TSY program will focus on learning motivations in context of the community and their values. In these neighborhoods, trying at school is frequently considered uncool and students choose to not-learn for this and other reasons. How can we purposively design for multiple narratives for participating in learning activities that allow for navigating around motivations to not learn?

The co-op will take donations of used computers from local organizations, refurbish them and sell and service them for the community. We are negotiating storefront space with local developers as part of the Westside Community Alliance and seek to leverage a donation of free broadband to the neighborhood as a motivation for community members to purchase computers from the co-op. The students working at the TSY Co-op would be trained to refurbish and service computers and would participate in CS educational workshops. This model, based upon the Glitch program, was successful in engaging young people with CS and demonstrating the value of higher education while still providing a face saving excuse for spending so much time on a learning activity. For students in these neighborhoods we suspect it is socially more acceptable to say, "It is my job, they pay me." or "I am helping out Ms. Edwards with her computer." than "I like to learn." Or "I want to learn about computers."

The TSY Co-op will also serve as an ongoing *living lab* to study computer science education, learning motivation and the ecology of learning to produce technology. We anticipate that multiple researchers will run programs through this co-op and the nature of the program will change as community members, participants, and researchers work together to define research goals and outreach needs.

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Learning, Games, and Affinity Spaces

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Summary of Research

In my work, I attempt to synthesize a number of perspectives related to digital media and learning and the study of informal learning contexts. My work to date has focused on *gaming, game design, and engagement within online communities*. My current research crosses through several established fields, including the learning sciences, educational technology, literacy studies, and the interdisciplinary field of game studies.

The theoretical frameworks I attempt to work through are sociocultural in nature (e.g., Lave & Wenger, 1991; Gee, 2004), while I also try to put studies of learning in conversation with media studies (e.g., Jenkins, 2006) and the emerging field of game studies (e.g., Bogost, 2007). I argue that a focus on digitally-mediated communication "in the wild" (Hutchins, 1995) should inform our understanding of learning and self-directed instruction. To date, my chief contributions to these perspectives on learning have been to explore Gee's (2004) concept of *affinity spaces* (recently explored in Hayes & Duncan, 2012), or informal online contexts for learning and affiliation. I seek to broaden the consideration of *collaboration* and *play* in social, interest-driven contexts and understand digital media not just as tools for use in designing better educational systems, but as *contexts for informal learning*. I challenge instrumentalist conceptions of technology in education, and employ theories of learning toward the goal of understanding participation in media cultures. The methods I have employed have been a mix of quantitative and qualitative. In Duncan (2010a) and Duncan and Berland (2012), we argued for stronger linkages between *content analysis* (Mayring, 2001; Weber, 1990) and *d/Discourse analysis* (Gee, 2010; Fairclough, 1995) as approaches to investigating learning in digital contexts. I have looked at interest-driven learning with other methods, including guided interviews with engaged child gamers regarding their gaming practices (Duncan, 2012).

I am currently developing future work along three major projects, each of which addresses digital media and learning, informal contexts for learning, and games. These are described in detail below.

Learning in Affinity Spaces

I have focused on understanding learning and expert practice within informal, online communities. This work began as a student with analyses of informal scientific practices in online communities (Steinkuehler, Duncan, & Simkins, 2007; Steinkuehler & Duncan, 2008). We focused on online talk in gaming communities, attempting to characterize the ways in which engaged participants in gaming spaces employed complex and valuable learning practices. At the time**,** we were interested in seeing how the discursive practices, scientific reasoning practices, and tacit epistemologies were exhibited in discussions of engaged *World of Warcraft* gamers. In my subsequent work, I have further investigated collaborative learning within these contexts. I have explored what Gee (2004) deemed "affinity spaces, delving into *design thinking* in these contexts (Duncan, 2010b), and, recently, I have written on the role of *contestation* as a driving motivator for online, interest-driven interpretive communities (Duncan, submitted). I recently co-edited a volume entitled *Learning in Video Game Affinity Spaces* (Hayes & Duncan, 2012), in which we pushed research in this area into new directions.

My next project in this area is applying the affinity space approach for understanding learning in informal, online contexts beyond gaming. I was recently awarded a 2013 Digital Media and Learning Research Competition on Badging and Badges Systems Development grant from HASTAC to investigate *social expertise* in online affinity spaces. This project, which will begin in May, 2013, involves characterizing how learning is displayed, negotiated, and contested in a range of informal online contexts (e.g., Reddit, Twitter hashtags, and gaming or hobbyist online forums). I aim to glean conclusions from affinity spaces that will guide design, and bring a focus on the participatory culture (Jenkins, 2006) of online spaces toward driving the development of effective digital credentialing systems.

In-Game Collaboration and Play

Games are often effective digital or non-digital contexts for learning, but they are also legitimate *expressive media* that are used for identity play, creating social connections, and transgressive purposes. In recent years, I have focused on two primary interests regarding games — *collaboration* within games and *creative production* within games. As opposed to the wing of my work that focuses on affinity spaces and online culture, I look at activities "in-game," or during play within a rule-based space in this set of projects. First, I have collaborated with Matthew Berland (UW-Madison) on a series of studies regarding face-to-face gameplay, computational thinking, and collaboration. Using the collaborative board game *Pandemic* (Leacock, 2007), we have used commercial strategic board games as testbeds to investigate the role of *computational thinking* (NRC, 2010) in rule-based play systems (Berland, Duncan, Boecking, & Tiger, 2012; Duncan, Boecking, & Berland, 2012). In future work, we aim to connect this work to interventions that will scaffold learners into computer programming. Building on authentic gaming practices, I plan to pilot a future program based on the digital game *Minecraft*. A key goal for this work is to explore games' designed constructive structures, and to develop instructional environments that can successfully balance authentic gaming practices with the development of design skills.

Designed Collaborative Gaming Spaces

Current work involves the design of novel games and learning contexts that incorporate the lessons learned from the other two running projects. Focusing on building meaningful affinity spaces *into* an educational game, I aim to better leverage the collaborative structures that are part and parcel of authentic gaming practices toward the design of better games for learning. The first step is a current collaboration (with IU's School of Business) on the design of digital game environment to support the learning of "global citizenship" skills. A key goal for this project will be to foster a set of global citizenship competencies (self-efficacy, empathy, understanding of globalization) through interaction in an affinity space that is tied to an educational game. The design of the system is underway, with implementation to take place in Fall, 2013. The goal of this branch of my research is to take insights from affinity spaces to *develop* online learning spaces around games.

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Researching Productive Connective Sites Where Interest, Learning, and Identity Intersect

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Research: Theory, Methods, and Future Plans

My research focuses on the productive *intersection of interest, learning, and identity* in kids' lives, seeking first to document and analyze connections between these areas and second to create and evaluate spaces that facilitate such connections. It is well documented that students struggle with their engagement in academic disciplines when spaces like school are felt to have different values, activities, and ways of being than home or other social spaces students value. In other words, when students feel a gap between who they are (or their "identity") at home and how they are supposed to act at school, their engagement and thus their learning suffer. This disconnect between identities in- and out-of-school tends to be more prominent among non-dominant students, and tends to exacerbate divisions of class, ethnicity, and gender. Yet when students feel more connected—when they feel like themselves in a subject area at school or in another learning setting—they tend to identify more strongly with that academic learning area. This has an additional and perhaps equally important benefit of encouraging students to think creatively by drawing on knowledge and practices across settings in their academic learning. Studying the connective spaces in kids' lives, those social settings that facilitate intersections between interest, learning, and identity, has two important values. First, we need better theories for understanding the relationship between engagement, interest, identity, and learning. Second, by understanding connective sites better, we can facilitate the development of such connections in students' lives to promote more equity and creativity in learning.

As part of supporting and studying the relationship between interest, identity, and learning I pursue three related research concerns: (1) Engaging kids in making interest-driven technological objects that unite interests and learning through the creation of objects; (2) Studying and providing design feedback on massive online spaces for children and youth that can act as connective spaces; (3) Developing blended methods that incorporate large scale data mining and ethnographic analysis in order to understand processes of learning, engagement, and identity development in both digital design making and massive online spaces.

Learning and Identifying through Making with New Technologies

Much research has focused on the importance of digital media in providing a means for social and creative expression in youths' daily lives. Yet the practices associated with "geeking out," those practices that involve the most fluency in technical design, have often been less accessible to youth, in particular because high tech communities have been described as a locked clubhouse culturally inaccessible or irrelevant to many women and other non-dominant students. Helping youth identify as part of these communities—through both their sense of self and their ability to participate in practices relevant to high tech communities (Fields & Enyedy, 2013)—is a challenge to broadening participation. Yet making engaging, hybrid artifacts that have relevance in multiple social arenas points to a possible way to mediate between the development of technical skills, personal relevance, and a broader sense of having a place in high-tech communities. In particular, creating artifacts with tangible yet interactive layers can facilitate relevance with multiple social groups in ways that support an individual's belonging in those different communities. In my research I consider the properties and processes of making such *technological objects* and how they can work as mediators that connect areas of youths' lives, including the opportunity to express personal interests, to build relevance with multiple social groups including friends, peers, and family members, and to develop pertinent technical skills.

My studies of students' making such connective and technological artifacts are currently in the context of two different technologies: the hybrid domain of electronic textiles (e-textiles) and the media-based visual programming environment of Scratch. In these areas I have delved into the what and how kids learn about crafting, electronics, and programming with e-textiles (Kafai, Fields & Searle, 2012), the role of aesthetics in promoting not just identification but increased learning with e-textiles (Fields, Kafai, & Searle, 2012), and the role of gender, interests, and prior expertise in students' identification with "tech" domains like computing and circuitry. Currently I am working on theoretical explanations of how the process of making these artifacts involves layers of learning and identification and how these artifacts can act as connective laminate objects that promote personal relevance as well as relevance with family, friends, and academic disciplines (Fields, Searle, & Kafai, in preparation).

In relation to Scratch I have been studying how different design challenges can promote learning of intermediate levels of programming while also engaging different audiences of youth (Kafai, Fields, Burke, Roque & Monroy-Hernandez, 2012). I have conducted these design challenges in both local workshops and the online social networking forum of Scratch.mit.edu, and often across both simultaneously, studying the role of community, collaboration, and constructive criticism in promoting learning and engagement with computing designs. I am also working on developing more fine-grained models of learning to program in Scratch. This research has implications for promoting diversity in fields of science, technology and engineering education in particular.

Studying and Designing Connected Spaces

There is great promise for learning technical literacies, developing social skills and contributing to our shared culture through participation in online sites. Indeed, kids are participating in growing numbers on online social sites, both at school and at home. Yet these sites are largely understudied and their educational potential generally untapped, especially in regard to children's participation in such sites, due either to societal fears about children's safety or impoverished designs (Grimes & Fields, 2012). Yet online sites can also serve as spaces for *connected play*, extending play from the everyday spaces of kids' lives at home, in school, in clubs and with friends into massive online websites where kids can take on new identities, engage in digital content creation, and learn from others (Kafai & Fields, in press). In a recent white paper I have argued for a broader look at children's play online, encouraging researchers to look at a wider range of social networking forums that children are likely to occupy, including virtual worlds, online games, do-it-yourself (DIY) based design sites, and networks accessed through console games (Grimes & Fields, 2012). Though in the past I have focused on virtual worlds (Kafai & Fields, in press), my current focus is on sites where children make and share designs, such as Scratch.mit.edu where social activity is centered around sharing video games, animations, and art created through programming. My goals include highlighting the ways that social networking and creative design can be mutually supportive, analyzing productive website designs, and illuminating children's own social and design innovations on such sites.

Developing More Robust Methods to Document Learning and Participation

Related to these studies of designs and online connective spaces, we must develop new methodologies for analyzing learning, social processes of identification, and interest development. I am currently pursuing ways to bring together ethnographic methods with educational data mining in an effort to better illuminate processes of learning to program with Scratch, children's online cultures of design, and the relationship between identity and learning with design. This involves developing new ways to process log files of online interactions (clicks, chat, "friend" links, uploads, downloads), collect and compare save states of computer programs, and analyze relationships between data gathered online or computationally (i.e. participation patterns, learning progressions) in addition to local social interactions, interviews, and aesthetic aspects of participants' designs. I am applying some of these methods in studying the online Scratch website to analyze participation patterns, programming profiles, and textual analysis of kids' comments to better understand the collaborative and supportive nature of the site for kids on a massive scale (Fields, Giang, & Kafai, 2013).

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Teachers as Learning Designers through Teachers' Design Thinking

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Abstract: Although greater attention has been paid to participatory learning environments in science education, researchers seldom point out that teachers benefit from interacting with students just as students benefit from interacting with teachers – which is one of central educational implications of Vygotskian theory. Hence, I aim to enhance what I call *design thinking*, teachers' active engagement in designing learning activities to meet the needs of 21st century digital learners.

Introduction

Recent advances in learning and instruction emphasize collaborative learning experiences in knowledge construction by immersing learners in authentic contexts that are often inaccessible without digital technologies (Dillenbourg, 1999). This research approach reflects a new understanding of how and where people are actually learning (Kim, 2012; Thomas & Brown, 2007). Learning is conceptualized as participation in socio-cultural activities (Vygotsky, 1997, 1997a) that are increasingly located beyond formal learning environments. Because of the rapid emergence of digital technologies, knowledge is no longer viewed as content within a specific domain. Rather, education needs to focus more on supporting learners in engaging in authentic inquiry and communities of domain-related practices – that is 'a participatory learning environment' (Barab et. al., 2001). In this light, the impact of model-based instruction is increasingly recognized as critical to providing learners with authentic inquiry learning experiences and transforming the way learners understand scientific phenomena (Schwarz & White, 2005).

In a similar vein, our research team (Kim, Lee, & Kim, 2011; Kim, Lee, & Ye, 2012) has designed the Embodied Modeling-Mediated Activity learning environments in informal astronomy workshops in Singapore. This research shows that although greater attention has been paid to participatory learning environments in science education, designing immersive, engaging and embodied learning experiences for students is still difficult for science teachers (Kim & Lee, in press). Researchers seldom point out that teachers benefit from interacting with students just as students benefit from interacting with teachers – which is one of central educational implications of Vygotskian theory. Hence, I aim to enhance what I call ***design thinking***, teachers' active engagement in designing learning activities to meet the needs of 21st century digital learners. To this end, this program of research will explore and enrich teachers' perceptions and experiences of design thinking by integrating a range of hands-on learning experiences (i.e., modeling designs) in a technology-rich context in order to help digital-age students engage in critical inquiry in both formal and informal learning contexts and develop their multiliteracy competencies, the ability to use a range of representation resources including images, sounds, and gestures to make meaning beyond reading and writing print-based texts (Barton, 2007; Kim, 2011).

This research effort will be strongly grounded in how research-based design principles, derived from a deep understanding of effective learning designs, can be infused into formal and informal learning contexts. To achieve these research objectives, three research questions will be addressed: What are effective ways to promote elementary science pre-service teachers' design thinking that engages students in critical inquiry and develops multiliteracy competencies?; How can we co-design immersive, engaging and embodied learning experiences with elementary science pre-service teachers in and out of the classroom?; and What are the socio-technological infrastructures needed for sustaining and supporting pre-service teachers' design thinking?

Theoretical Framework

The theoretical framework for this study comes from three interrelated design features of a participatory learning environment, drawing on Vygotskian cultural-historical activity theory (Cole, 1988; Engeström, 1987; Vygotsky, 1997); and my previous research in designing immersive, engaging and embodied learning activities for promoting science learning: creative apprenticeship, empathic participation, and embodied experiences.

Methodology

Drawing on this theoretical framework, this program of research will require investigation into the actual practices of involving pre-service science teachers' design thinking toward developing immersive, engaging and embodied learning activities for digital-age learners. It is essential for the researchers to become engrossed in the research participants' situations through developing reflective practices (Eisner, 1991; Kim, 2014), which will be required to respond to emerging participants' interests, abilities and challenges and to co-design, enact and reflect on the multimodal modeling activities. In this light, the Design-Based Research (DBR) (Collins, Joseph, & Bielaczyc, 2004; Confrey, 2006) approaches will be effective for the researchers to become more open, flexible and creative to identify critical elements of the design processes through implementation and modification responding to authentic contexts. By retrieving both the successes and failures from the implementation (Barab, 2006), the success of implication will contribute to the development of new theoretical insight to the theoretical framework. Hence, DBR will make a contribution to practice (enhancing teachers' design thinking of a multimodal modeling-integrated curriculum) and to theoretical understanding (developing a theory of teachers' design thinking across formal and informal settings) toward sustainable structures of teacher professional development.

Implications

Drawing on Vygotskian cultural-historical activity theory and my previous research in digital Learning Design with teachers and other school stakeholders, this program of research has implications for make theoretical advances in our understanding of Vygotskian and related theories such as embodied cognition integral to modeling-based teaching and learning, by identifying design principles that foster embodied cognition, the interplay between perceptional and motor behaviors and conscious cognitive processes. It will also promote pre-service teachers' design thinking toward designing modeling-based multiliteracy practices and creating a participatory learning environment to transform teacher education and professional development for digital-age students.

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Collaboration and Learning in Online Communities: Summary of Research

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Introduction

This extended abstract describes my research starting with dissertation research moving through to current research focusing on learning and collaboration in online communities.

Dissertation Research

My dissertation, entitled *Information Literacy in Interest-Driven Learning Communities: Navigating the Sea of Information of an Online Affinity Space*, comprised a mixed methods approach to understanding information literacy practices in naturalistic contexts of game communities, particularly in *World of Warcraft (WoW)*. Information literacy is a 21st century literacy as described by the Partnership for 21st Century Skills, and is broadly defined as the ability to find, evaluate, and use information to solve a given information need. This study used methods of information horizon maps as well as a priori coding, and quantifying qualitative codes, and used the framework of learning ecologies as a lens in which to view the online community. Information horizon maps was a method that comes from information science which was adapted for studying information and identity as it relates to learning. The findings of this study paint a broad picture of people's use and development of information literacy practices taking into consideration the collaborative nature and collective intelligence of massively multiplayer online game spaces. The communication and collaboration between members of the community is essential for the success of the community members solving information needs related to their game play. Participants for my data set included the *WoW* community at large and a group of 22 youth males who were members of an afterschool lab, which served struggling and disengaged students mainly from working class, rural and urban environments, youth whose practices are sometimes overlooked in traditional school settings. This study created a descriptive model for information literacy practices in use in digital communities in people's daily lives, re-theorizing information literacy as increases in communal knowledge, and examined the effect of collective intelligence and collaborative activities on people as they move from novices to more advanced and more knowledgeable participants.

Current Research

My current research focuses on two main projects. The first project is the development of a body of research that examines the relationship between collaboration, literacy, and information practices in the online communities for *Team Fortress 2, Elder Scrolls: Skyrim,* WWE*,* and Hunger Games. This project examines connected learning in the communities as well as the transformation of users to collaborators and contributors. This work uses a mixed methods approach combining community observations, interviews, coding, information literacy analysis, and quantifying qualitative codes.

The second and larger project I am engaged in is conducting research on connected learning practices in the community surrounding professional wrestling fan culture and fantasy wrestling, especially WWE fans. Connected learning explores how people connect learning and activities from one part of their life to the rest of their life, for example do they use skills they learn in school in their WWE space and vice versa. It also emphasizes the importance of mentorship when using skills across contexts including developing skills from interest that can feed into a career track. This work focuses on youth learning practices in these spaces. I use ethnographic methods including long term community observation as well as interviews with community participants plus a community gate keeper, in this case the forums founder and main administrator. The interviews and field notes from observations are coded using an a priori coding scheme based on the connected learning principles.

My research aims to identify and evaluate learning practices including those of information literacy and to make models of those practices, which connects the skills people use in various environments to help them more effectively communicate and use information. Connecting the practices that people use in their leisure spaces to academic situations is necessary for the democratization of information and creating a more informed citizenry. My research pushes the boundary of digital media, information science and education connecting the disciplines to strengthen learning and information practices which are crucial to being successful in 21st century learning. The mixed methods approach used allows me to conduct thorough qualitative research, firmly based in the theoretical framework of learning ecologies.

Research Statement

The collaborative design of technologies that scaffold and assess during web-based science inquiry

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Abstract: I am a postdoctoral scholar with Marcia Linn at the Technology Enhanced Learning in Science (TELS, telscenter.org) center. I play leading roles in research, technology design, grant writing, and teacher professional development. I am particularly involved in the NSF-funded projects, *Visualizing to Integrate Science Understanding for All Learners* (VISUAL), and *Continuous Learning and Automated Scoring in Science* (CLASS). More on my work can be found at https://sites.google.com/site/cfmatuk/

Research Overview

My current research is organized around two main questions, each concerned with the creative, collaborative, and learning processes surrounding educational technologies: (1) How can we best design tools that address the challenges of managing information during inquiry-based STEM learning and instruction? And (2) how can we support successful collaborations surrounding designing innovative educational technologies? I conduct design-based research into the cognitive, social, and representational issues surrounding the uses of technology in teaching, learning, and design, particularly among middle and high school students, science teachers, and learning scientists.

Two main perspectives guide my work. One is Knowledge Integration (KI), a pedagogical framework that views students' initial understanding as fragmentary and idiosyncratic; and that specifies effective instruction as supporting the elicitation of ideas, the addition of scientifically normative ideas, and personally meaningful activities that help students sort, organize, and distinguish among those ideas toward an integrated conceptual understanding (Linn & Eylon, 2011). The second perspective integrates user-centered design (UCD) and Agile development (da Silva et al., 2011) to emphasize the early and regular involvement of users in rapid iteration between establishing requirements, designing alternatives, and building and evaluating prototypes. This dual approach enables me to simultaneously elaborate principles behind successful collaborative learning technologies; refine their design; and understand how they mediate learning and instruction within integrated socio-technical systems of practice.

Current and Ongoing Projects

Tools to Continuously Scaffold and Assess During Science Inquiry

How do learners track, distinguish, and reconcile new and existing information? And how do teachers insights from student work to adapt their instruction? To some extent, the challenges of science inquiry learning and instruction are in managing the large amounts of information encountered. Recently, I have been leading the design and implementation of new tools in the Web-based Inquiry Learning Environment (WISE, wise.berkeley.edu) intended to support student inquiry and teacher decision-making by providing better ways for them to interact with information over the course of extended web-based activities.

Two tools integrated into the WISE student interface are designed to scaffold key processes in science inquiry, and to provide alternative outlets through which students with diverse abilities may demonstrate their understanding. For example, the *Image Annotator* promotes observation by allowing students to label given pieces of visual evidence. Integrated into WISE, the *Annotator* logs students' revisions to their labels along with their other interactions in a unit. Classroom trials with a unit on mitosis (http://wise.berkeley.edu/webapp/preview.html?projectId=6498)showed the *Annotator* to support discussions of microscopic evidence, as well as to reveal students' developing observational skills (Matuk & Linn, 2013).

Another tool, the *Idea Manager*, breaks down the process of writing scientific explanations into discrete, more manageable steps. The Idea Manager supports reflection by providing students with a virtual space within which to collect, sort, and organize information in preparation to write a narrative explanation. Classroom trials of the tool show how it encouraged students to negotiate shared criteria for distinguishing their ideas (Matuk et al., 2012); made students' ideas visible for teachers to provide formative guidance (Matuk & Linn, 2013); and provided a record of students' changing ideas over time. This record allowed researchers to identify what ideas are most difficult, in what ways, and for whom (McElhaney et al., 2012).

We are currently testing collaborative features in the Idea Manager, which allow students to exchange ideas (Matuk et al., 2013). In recent classroom trials, we see how students decide to select from and share ideas with their peers, and the impacts of sharing on students' individual repertoires of ideas.

Altogether, these tools (1) Give researchers insight into how people learn by providing a richer picture of students' trajectories than typical end-of-unit tests; (2) allow designers to identify specific impacts of online materials on students' understanding, which can inform targeted design revisions; and (3) inform teachers how to adapt their instruction toward students' individual needs.

Tools to Orchestrate Classroom Inquiry

With the development of the tools above, as well as of new automated scoring systems in WISE, teachers will have access to more nuanced data on their students' progress. Capitalizing on this affordance, I have begun to investigate ways to integrate tools into teachers' uses of WISE that would help them better adapt their instruction and assessment during extended science inquiry activities. These investigations involve ethnographic observations of teachers' classroom management practices, in-depth participant interviews, focus groups, user studies, and professional development activities. This work will inform the iterative design of data visualizations and real-time classroom monitoring and communication tools to support teachers adopting effective guidance practices during science inquiry.

Factors that Support Collaborative Design Communities

In addition to investigating the learning outcomes of designed educational technologies, I have recently been seeking to understand how technology mediates design collaborations among cross-disciplinary participants. Thus, I actively document the collaborative design process between myself and my collaborators through such means as archived electronic correspondence and intermediate design artifacts. In doing so, I expect to draw insights into the factors that sustain hybrid online/offline collaborations among teachers, students, researchers, and technology designers, and to better understand the design practices that make educational tools successful.

Conclusion

I am committed to an iterative approach to design that is both a participatory and reflective process. Not only does this approach inform design, but it also reveals more about how people create, learn, and collaborate with technology. As I extend my research to other tools and contexts, I will continue to pursue what it means for people to engage in design as learners, educators, and researchers, with a focus on how technology mediates creativity, cognition, and collaboration. Moreover, I will continue to investigate how the practice of design can inform both theory and practice.

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First let me state that very recently, on January 11, 2013, I graduated with distinction, cum laude, after having defended my PhD thesis entitled 'Fostering Argumentation-Based Computer-Supported Collaborative Learning in Higher Education'. My research was supervised by prof. Martin Mulder (promotor), dr. Harm Biemans (co-promotor), and prof. Armin Weinberger (co-promotor). I will continue my career as Assistant Professor in Tenure Track at the Education and Competence Studies (ECS) Group, Wageningen University.

My doctoral dissertation looked at the effects of Computer-Supported Collaborative Learning (CSCL) platforms and their functionalities on both disciplinary and interdisciplinary learning. In my research, I designed various types of instructional interventions, e.g. scaffolding and scripting approaches, and tested their effects on a variety of learning process and outcome aspects in both real educational and control-based laboratory settings. My research program has covered a wide range of qualitative and quantitative methods to analyze various aspects of learning processes and outcomes in CSCL environments.

This research project has been the subject of many papers I have delivered at international conferences and various articles published in peer-reviewed ISI journals, such as *Computers in Human Behaviour, Educational Technology Research and Development, Educational Research Review, Learning and Instruction, International Journal of Computer-Supported Collaborative Learning, Computers and Education*. Based on these accomplishments, Wageningen University granted me a junior research award in 2010. This award was realized in the form of a visiting scholarship at the University of Michigan under the direction of Prof. Stephanie Teasley. In addition to networking and the exchange of ideas and information, this fruitful collaboration has resulted in some conference papers, and publications.

My current research focus is on scripting CSCL environments to facilitate argumentative knowledge construction and learning in real educational settings. Scripts have been shown to be a promising approach to orchestrate various roles and activities of learners. CSCL scripts can be used as an approach for procedural scaffolding of specific interaction patterns implemented into online learning environments. The purpose is to foster transactive knowledge sharing and domain-specific knowledge transfer in a CSCL setting using transactive memory and discussion scripts. A transactive memory script is a set of "role-by-expertise" prompts for building awareness about a learning partner's expertise, assigning and accepting task responsibility, and forming a collaboratively shared system of retrieving information based on specialized expertise. A transactive discussion script is a set of "elicit-and-integrate" prompts for making analyses of the argument(s) put forward by learning partners and constructing arguments that relate to already externalized arguments. In addition, I would like to investigate the individual and combined effects of these two kinds of scripts on the quality of both joint and individual problem solutions.

Although my dissertation and publications have focused primarily on CSCL and digitally-supported learning environments, my research interests also encompass the development of improved models and methods for the design, evaluation, improvement and upgrading of educational technologies, digital media, digitalized game-based learning, Web 2.0 environments, and e-learning and distance education in educational settings. Specifically, I would like to design digital games for facilitation of argumentation. Learning argumentation through game and technology is based on a socio-constructivist perspective in which learners acquire essential aspects of argumentation by practicing them, rather than reading and thinking, while engaging in an active dialogic process with learning partners. A promising approach to include motivational aspects of learning is to design educational games with technological innovations that provide learners with a great deal of opportunities for argumentation-based learning. In such a combination of learning with fun, games provide learners with a pleasant learning environment that can stimulate motivational aspects of learning, whilst the support from the technology offers the possibility of acquiring argumentation skills through scaffolding of argumentation.

Researching orchestration

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Abstract: As an early post-doctoral researcher with prior experience in the telecom industry, I am highly interested in the challenges of applying CSCL research in authentic educational settings (what some authors call "orchestration"). This brief document provides a short summary of my CSCL-related research delving into that multi-faceted and ill-defined problem, including conceptual frameworks, technological systems and approaches to professional development of practitioners.

Research summary

Computer-Supported Collaborative Learning holds the promise that collaborative learning can be made more effective and efficient by the use of ICT. However, in formal education practice we seldom see this promise fulfilled: the introduction of novel technologies and pedagogic approaches in the classroom often puts new burdens on teachers and students, with the net result being that innovation is scarce and technology appropriation, painfully slow. My main research interest dwells in *how CSCL research can be successfully applied within the constraints of authentic educational settings*, a concern that in the last few years has crystallized around the term "orchestration" (Dillenbourg et al., in press).

This research interest on CSCL and the topic of orchestration, which might seem odd for a person with mostly technical background, is the consequence of an atypical career path. Initially a software developer in the telecom industry, I engaged in grid computing research. Since I found research work more rewarding than my prior roles in the industry, I decided to pursue an academic Ph.D. degree. More concretely, I set out to do multi-disciplinary CSCL research work at the GSIC-EMIC group (1) in the University of Valladolid. Along this journey, I have always been interested in how technology shapes the way we think and do things, and vice versa. This motivation, along with my fieldwork in authentic educational settings (e.g. primary schools, but also in higher education), where I've seen teachers and students striving to integrate new technologies and pedagogical practices, has led to my current research interest on how to facilitate the "orchestration" of authentic CSCL scenarios.

My research in the field of CSCL so far has touched upon a number of theoretical frameworks, such as design thinking or activity theory. However, the lack of an established analytical lens to study the problem of orchestrating CSCL, led our research group and other researchers to propose a *new conceptual framework* that could serve to analyze more methodically this multi-faceted problem. This '5+3 Aspects' framework (Prieto et al., 2011a) represents the first contribution of my Ph.D. thesis, and has already been used to analyze and evaluate several technological innovations applied to authentic classroom settings, both by our research group and by other researchers.

I have also made other contributions, both in the conceptual and technological sides of the orchestration problem. We proposed the notion of 'atomic patterns' as *practices of value to aid non-expert teachers in orchestrating complex CSCL situations* (e.g., in professional development actions, see Prieto et al., 2011b). These atomic patterns are extracted from the observation of successful CSCL practice, and they are similar to other design patterns. They have, however, certain particularities (e.g., they are of smaller granularity and contain explicit references to classroom contextual elements), to make them easier to identify and use by practitioners.

In the technological side of the orchestration problem, we have proposed GLUE!-PS (2) as a *system to support non-expert teachers in orchestrating blended, web-based CSCL* that involves Virtual Learning Environments (VLEs) and other external "Web 2.0" tools (see Prieto et al., 2011c). This service-based architecture can be used to deploy learning designs (e.g., CSCL scripts), expressed using multiple computerized formats, across different flavors of these distributed learning environments, also enabling the management of the resulting scaffolding in run-time. Aside from being available as open source, the system is naturally extensible, and requires little or no modifications to existing infrastructures available at institutions, thus increasing the feasibility of its application to authentic educational settings.

During my work in the Ph.D. thesis, and also in the ongoing follow-up work that is being conducted at the moment, we have mainly used an iterative research process typical in software engineering (inform, propose, analyze, evaluate – see Glass, 1995), which resembles in many ways other methods more typically used in CSCL such as design-based research. Especially important in this regard are the evaluations conducted so far, which have followed a mixed methods approach derived from the one proposed by Martínez-Monés et al. (2006). The data gathering and analysis, which had more emphasis on the qualitative side, was in some cases guided by the aforementioned '5+3 Aspects' framework, as a way to assess more systematically the support that the proposed conceptual and technological tools provided to the multiple challenges of orchestration in authentic settings.

Current and future work

More recently, during my post-doctoral research still at the GSIC-EMIC research group in the University of Valladolid, we are continuing several lines of work that my Ph.D. thesis first opened. A considerable part of my current work is related to the METIS European LLP project (3), which explores novel ways of *supporting practitioners in learning design thinking*, through the combination of professional development actions (e.g. teacher workshops) and supporting technological environments. This path was started during the evaluation of the atomic patterns and the GLUE!-PS system during my Ph.D. thesis work, where authentic professional development actions played a crucial role. Another important thread of current work is the *extension of the technological support for orchestration* that GLUE!-PS provided for web-based Distributed Learning Environments, beyond web-based activities (e.g. in physical spaces by the usage of Augmented Reality techniques, or through tabletop interfaces). This line of work is now being explored in the context of a Spanish national research project (4), as well as through an ongoing Ph.D. thesis and ad-hoc collaborations with other research groups (e.g., the CHAI group at the University of Sydney).

Aside from these lines of work, which stem directly from my thesis work, in January 2014 I will start doing research at Pierre Dillenbourg's CRAFT group in the École Polytechnique Fédérale de Lausanne (EPFL), Switzerland. In this upcoming endeavor, framed within a Marie Curie Intra-European Fellowship (IEF), we will explore the possibility of *modeling the orchestration of authentic face-to-face CSCL classrooms*, and we will focus especially on proposing new ways of *facilitating such orchestration through paper and tangible user interfaces*.

Endnotes

(1) See http://gsic.uva.es (Last visit: 9 Apr 2013).
(2) Available at http://gsic.uva.es/glueps (Last visit: 9 Apr 2013).
(3) Lifelong Learning Programme project 531262-LLP-2012-ES-KA3-KA3MP, see http://www.metis-project.org/ for more details (Last visit: 9 Apr 2013).
(4) EEE: Orchestrating Educational Reflected Spaces, project TIN2011-28308-C03-02, see http://eee.gast.it.uc3m.es for more details (Last visit: 9 Apr 2013).

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Scaffolding collaborative knowledge integration of students and teachers through visualizations

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Abstract: What scaffolds can support students and teachers to collaboratively integrate their knowledge in technology-enhanced environments, particularly in science education? This guiding question connects both my doctoral and postdoctoral work. A particular focus of my research is on how different forms of visualizations can scaffold collaborative knowledge integration activities. For my doctoral research, I developed and investigated a technology-enhanced online learning unit on human evolution with a novel form of concept map to support collaborative knowledge integration processes. My post-doctoral research focuses on how groups of teachers collaboratively design and revise learning units in a technology-enhanced environment.

My doctoral research focused on scaffolding students while my post-doctoral research focuses on supports for teachers. In my doctoral dissertation research (Schwendimann, 2011), I investigated how different forms of concept mapping embedded in a collaborative technology-enhanced learning environment can support students' integration of biology concepts using case studies of human evolution. I used Knowledge Integration (KI) (Linn & Hsi, 2000) as the operational framework to explore concept maps as knowledge integration tools to elicit, add, critically distinguish, group, connect, and sort out alternative evolution ideas. Concept maps are a form of node-link diagram for organizing and representing connections between ideas as a semantic network (Novak & Gowin, 1984). I developed a novel biology-specific form of concept map, called Knowledge Integration Map (KIM) using a design-based research approach (Brown, 1992; Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003). Three iterative studies were implemented in ethnically and economically diverse public high schools classrooms using the web-based inquiry science environment (WISE) (Linn, Clark, & Slotta, 2003). The studies systematically explored generating or critiquing Knowledge Integration Maps as collaborative learning tools for biology education. The online learning environment and KIM activities were developed in collaboration with science teachers, scientists, computer scientists, and education researchers. I identified effective design patterns to implement KIMs in an inquiry-based learning environment and distinguished the learning effects from either generating or critiquing KIMs as embedded learning tools. Findings suggest that critiquing KIMs can be more efficient than generating KIMs. Using KIMs that include common alternative ideas for critique activities can create genuine opportunities for students to critically reflect on new and existing ideas. Critiquing KIMs can encourage knowledge integration by fostering self-monitoring of students' learning progress, identifying knowledge gaps, and distinguishing alternative evolution ideas. My doctoral research demonstrated that science instruction of complex topics, such as human evolution, can succeed through a combination of scaffolded inquiry activities using dynamic visualizations, explanation activities, and collaborative KIM activities. This research contributed to educational research and practice by describing ways to make KIMs effective and efficient learning tools for evolution education. Supporting students' building of a more coherent understanding of core ideas of biology can foster their life-long interest and learning of science.

In my post-doctoral research, I shifted my focus to scaffolding collaborative curriculum design activities of K-12 and higher education teachers (both pre-service and in-service). The process of collaborative technology-enhanced educational design conducted by inter-disciplinary teams is not well understood. Together with my team, we set up a new facility, the educational research studio (EDRS), to study technology-enhanced collaborative design activities of groups of teachers (Schwendimann, 2013). Design studios are well established as settings for collaborative work in creative disciplines, such as architecture, art, and product design. Design studios provide users with spaces for experimentation, frequent formal and informal critique, and physical and digital tools to work collaboratively on complex design problems. However, empirical studies of educational design are rare, and studies in studio settings even rarer. I am collecting data using the newly built EDRS which (i) is equipped to support small teams of people (between two and ten) engaged in existing or newly created educational design problems, using their own or design methods and resources that we make available, while (ii) allowing us to make clear audio-visual recordings of all members of the design teams, sufficient to transcribe and/or annotate key passages in the design process, and to playback such passages for stimulated recall debriefings with the designers. We are capturing the design discourse, gestures, expressions and other important elements of non-verbal communication within the design team, and the evolving state of their design artefacts.

The goal is to develop a deep understanding of collaborative practices of design-for-learning and improve design-for-learning by providing better tools and methods that are consistent with current scientific understanding of how people learn. I am collecting data from design teams working on design-for-learning projects. My research uses constructs from activity theory and is influenced by anthropological studies of traditional work practices and participation in communities of practice, naturally occurring and artificially created knowledge-building communities, and networks. Data collection includes discourse, gestures, artefacts construction, tool usage, and space usage. These rich datasets allow triangulating the complex interactions during collaborative educational design work. Research in the EDRS focuses on two types of studies: self-directed studies and experimental studies. In the self-directed studies, groups of designers are working on their own projects using their own tools, scripts, and representations. The research goal for this condition is to gain a deeper understanding of existing collaborative design-for-learning practice. Findings from studying self-directed design will inform the development of methods and tools for the experimental studies. In the experimental studies, participants receive tools and methods provided by the researchers. These are informed by the previous set of studies but may include tools to support the design process such as instructional design tools or different design processes such as the Stanford d.school design method (Stanford d.school Design Method, 2013). The research goal for the experimental studies is to iteratively develop a framework to effectively and efficiently support collaborative groups with a focus on design-for-learning. Data analysis focuses on five different areas: Usage of tools, stages in the design process, roles in the design process, forms and usage of representations, and usage of digital and physical space. Findings from my studies will be valuable for improving design-for-learning for inter-disciplinary instructional design teams. Better tools and methods for collaborative design-for-learning contribute to improving the quality of instructional design, make the instructional design process more efficient, and raise learning outcomes. My iterative research studies will implement methods and tools that support design for learning consistent with current scientific understanding of how people learn.

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Technology Enhanced Mathematics Learning Environments

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Abstract: Physically representing and acting out mathematics problems has the potential to support student learning. In my research, I am using motion-controlled technology to develop learning environments that teach geometry concepts to elementary and middle school students. I am examining students' perspective taking as they learn. Also, using log data tracking students' actions within these environments, I am classifying successful and unsuccessful sequences of actions students make.

Introduction

Success in mathematics is critical in order to be competitive in an increasingly information-based, global market, yet less than half of all US high school graduates meet college readiness requirements in mathematics (McCormick & Lucas, 2011). The call for reform in mathematics education is not new, but the need is becoming more critical. Incorporating technology and recognizing the body as a resource for mathematical reasoning are possible ways to significantly change how students learn and teachers teach. Using a theoretical framework of embodied cognition, I have been studying the affordances of full body interaction both within and outside of technology-enhanced learning environments. I am examining whether or not physical learning experiences can make a difference in achievement. Body-based learning activities have the potential to support a greater number of students in engaging in and developing a strong understanding of mathematics. The long-term goal of my research is to determine key instructional strategies that promote success of children learning mathematics through relevant, interactive experiences that increase interest, engagement, understanding, and achievement.

Background

Contrary to classical theories of cognition, which emphasize a split between the functions of the mind and the body, the theory of embodied cognition recognizes that the mind and the body work closely together with the environment to help us make sense of the world (Glenberg, 2010; Barsalou, 1999). Physical experiences related to mathematics content have been shown to be effective at improving mathematical reasoning. Howison, Trinic, Reinholz, and Abrahamson (2011) found when students moved their hands to simulate proportional relationships while interacting with a Wii game, they developed more advanced understandings of proportional equivalence. Walkington et al. (2012) found that directing students' movements when problem solving led to a more meaningful understanding of geometric proof. Similarly, in a case study, Wright (2001) showed how physically acting out motion problems helped a student better understand rate of change. The potential for physical activities to positively impact learning is encouraging, but there is a need for a better understanding of how students assign mathematical meaning to their actions.

Methods

I am working primarily with middle and secondary students, and I am developing and studying a series of motion-controlled learning environments using Kinect for Windows that teach different geometry concepts. The learning environments log spatial data of students' bodily movements as they progress through the environment. I use pre- and post-assessments to track learning gains, and I collect data on students' cognitive-affective states while they are playing using the Baker-Rodrigo Observation Method Protocol (BROMP 1.0) (Ocumpaugh, Baker, Rodrigo, 2012). The BROMP data is time-stamped and can be synced with the log files from the Kinect game. I use a combination of one-on-one design experiments with a teacher-researcher (Cobb et al., 2003) and experimental classroom studies to examine how students learn.

Previous Work

In my early work applying embodied cognition theory to instruction, I studied a kindergarten mathematics class learning about patterns. I found differences in the ways students talked about patterns depending upon whether or not the activity was embodied (Petrick, 2011). When the class physically enacted patterns, students used more first person language and noticed different kinds of mathematical relationships than when they made patterns with manipulatives. In my work in computer science, I found that students naturally use their bodies to act out and solve problems while learning to write code in mobile, social environments (Smith, Berland, & Martin, 2012; Petrick, Berland, & Martin, 2011).

These studies led me to hypothesize that physically acting out problems could support conceptual development better than traditional instruction. To test this conjecture, I worked with 162 high school students who participated in a two-week unit on similarity under one of two conditions. One group physically represented and acted out mathematics concepts, while the other watched abstract simulations or drew pictures. Results showed that both conditions learned over the course of the study; however the group that physically acted out concepts had significantly greater gains, particularly in the area of conceptual understanding (Petrick & Martin, 2012; Smith & Martin, 2013). These findings offer exciting potential for embodied learning experiences. The next step in my research combines embodied cognition, learning, and motion-controlled environments.

Current & Future Work

I have begun using motion-controlled learning environments as both instructional and data collection tools. This will allow the categorization and analysis of specific sequences of students' physical movements that do and do not support learning. Motion-controlled technologies can record spatial data of students' physical movements. This enables me to overcome a challenge I faced in some of my prior studies, as I was unable to capture and track how students' actions changed over time. The log data will allow me to engage in a fine grain analysis of the relationship between students' actions and learning that was not previously possible.

In addition to looking for successful patterns of actions, I am researching the role of perspective taking in embodied learning. When students become actors in mathematics problems, their perspective on the problem changes. Instead of viewing the problem from an external perspective, they are now "in the action" so to speak. I hypothesize that one of the reasons embodied activities support learning is that students are prompted to take multiple perspectives. I am examining whether specific design features of motion-controlled environments encourage taking multiple perspectives, and I am looking at how this impacts students' movements and learning.

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Volume 2

Invited Papers

Looking Back and Looking Ahead: Twenty International Years of CSCL
Invited Presidential Symposium

Organizers: Frank Fischer, Ludwig Maximilian University, Munich, Germany, frank.fischer@psy.lmu.de; Cindy Hmelo-Silver, Rutgers University, USA; cindy.hmelo-silver@gse.rutgers.edu; Susan R. Goldman, University of Illinois, Chicago, USA, sgoldman@uic.edu.

Discussant:
Nikol Rummel, University of Bochum, Germany, nikol.rummel@rub.de

Abstract: The contributors analyze the research and the development of the CSCL community in their respective regions of the world. Questions they address include the following: What were the origins and early stages of CSCL in this area of the world? What have been important research questions, concepts and methods? Which unique contributions to CSCL research have there been from this area of the world? Looking ahead, what future trajectories can be expected – and what would be a desirable future of CSCL research? Nancy Law will contribute her perspective on CSCL in Asia, Peter Reimann analyzes CSCL research in Australia, Paul Kirschner and colleagues present their view on CSCL research and communities in Europe, and Gerry Stahl will present his view on CSCL in North America. In the role of the discussant, conference program co-chair Nikol Rummel will provide a synthesizing perspective on historical and future trends, especially with respect to their presence at the current conference

Overview
Twenty years after the first conference on computer-support for collaborative learning, four contributors analyze the research and the development of the CSCL community in their respective regions of the world. Questions they address include the following: What were the origins and early stages of CSCL in this area of the world? What have been important research questions, concepts and methods? Which unique contributions to CSCL research have there been from this area of the world? What have been the role and the relation of different disciplines within CSCL research, e.g., computer science, psychology, educational sciences? Looking ahead, what future trajectories can be expected – and what would be desirable - futures of CSCL research? The discussant will reflect on the presence in the current conference of the trends analysis presented in this symposium.

CSCL in Asia
Nancy Law, University of Hong Kong, nlaw@hku.hk.

CSCL research in Asia was stimulated in the 1990s by the formulation of IT masterplans in a number of countries and focused on improving education system-wide and preparing citizens for the 21st century. There is strong interest in linking research and practice and an orientation toward collaborative knowledge building. The CSCL research conducted in Asia emphasizes a strong focus on pedagogy and assessment, bringing with it the challenge of integrating CSCL into the daily instructional milieu. A second emphasis in Asia is on teacher learning and professional teacher networks for knowledge building, Looking to the future, CSCL in Asia needs to take up the challenges inherent in research on CSCL at individual, group, and community levels.

CSCL in Australia
Peter Reimann, University of Sydney, Australia, peter.reimann@sydney.edu.au

The main "driving" discipline behind CSCL research in Australia is applied computer science, in particular in the form of technology developments in higher education. CSCL is a main research interest area,at the University of Sydney, one of the few places where there is a large concentration of researchers interested in collaborative learning. Australia's innovative contributions to CSCL currently include tabletop computing in support of co-located, synchronous group work and group learning, collaborative web-based video annotation, and collaborative (academic) writing as a form of CSCL. Likely trajectories for future research are those focused on media-rich (synchronous) collaboration, including video conferencing and collaboration in immersive environments; increasing use of learning analytics in the context of CSCL studies, and studies into collaboration processes in design teams and virtual design studios.

CSCL in Europe – Unity in Difference

Paul Kirschner, Open University of the Netherlands, Heerlen, The Netherlands, paul.kirschner@ou.nl

The hallmark of European CSCL is its diversity. Across Europe, research groups are designing tools for CSCL and studying their implementation in terms of duration, scripting, and social dynamics. Aided by national, transnational and European programs, Europeans regularly work with and meet with each other, learning from each other in Networks of Excellence and European schools. This presentation reflects the cross-national collaboration in CSCL research in that researchers from 10 countries will provide input into the content of this presentation. The future promises continued cross-national efforts.

CSCL in North America

Gerry Stahl, Drexel University, Philadelphia, USA, gerry.stahl@gmail.com

For many of the leading early North American CSCL researchers, the goal was to use CSCL innovations as levers to transform education by promoting collaborative learning and investigating the interaction within the group and the group processes related to social dynamics as well as knowledge building. Research addressed aspects like design of technology, analysis of collaborative learning, and the evaluation of collaborative learning outcomes. A major contribution of North America to CSCL research has been the emphasis on design-based research, in which iterative cycles of trials in realistic settings are used to drive design of technology and pedagogy. Future trends in CSCL research are toward increasing international collaborations and projects (for historical details, see http://GerryStahl.net/pub/cscl2013presidential.pdf).

How will Collaborative Problem Solving be assessed at international scale?

Chee-Kit Looi, National Institute of Education, Singapore
Pierre Dillenbourg, École Polytechnique Fédérale de Lausanne, Switzerland

Abstract: This workshop seeks to create awareness in the CSCL community of the international efforts to assess Collaborative Problem Solving (CPS). There are at least two well-known efforts in this area. First, OECD is planning to include the assessment of CPS in PISA 2015. Second, there is the initiative by ATC21S to assess how pairs of learners working collaboratively solve a problem through digital tools. The workshop speakers are scholars involved in defining the frameworks for assessment and the competencies and skills to be assessed, as well as designing the collaborative task items and the assessment methods. A second goal of the workshop is to collect feedback from the CSCL community about the feasibility, design, implementation, validity and challenges of these assessments. A third goal is to reflect on how countries, regions and boards or ministries of education might prepare students to become better collaborative problem solvers and learners.

The Innovations in Learning and Education SAVI

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Jari Multisilta, Helsinki University, Helsinki, Finland, jari.multisilta@helsinki.fi

Abstract: This poster highlights a "Science Across Virtual Institutes" SAVI, involving sixteen research teams in Finland and the USA. The groups have formed a collaboration of eight teams (one research group from each country per team) devoted to research and development in learning sciences and technologies. The core unifying theme of the SAVI is a mission to find conditions under which immersive learner engagement can be routinely elicited.

Introduction

This Finland-USA collaboration responds to the NSF Dear Colleague Letter (DCL) of 24 October 2011, "Introducing Science Across Virtual Institutes (SAVI)" (NSF 11-087). A group of research teams from the USA and from Finland has formed a SAVI as a knowledge network that will interconnect the teams through common intellectual themes and educational innovations. The SAVI seeks to hasten discovery and knowledge sharing, and to facilitate the broader impact of the teams' findings in our countries' respective STEM education enterprises.

In SAVI planning, discussion repeatedly returned to one of the most important areas in education, learner engagement. This research area can be expressed in many questions, a prototype of which is – under what conditions can learners become unreservedly absorbed or immersed in challenging subject matter? It is precisely this question that arose from multiple vantages at a June 2012 workshop designed to advance the SAVI possibilities. Learner engagement is not content-independent, and it involves both cognitive and affective components. The pathways consistently proving to engage learners vary depending on context and area of interest (e.g., extracting scientific structure from video artifacts; building complex reasoning skills in game settings; authoring media to express engineering principles, etc.). They have different objectives (e.g., software testing; scaling intervention; refining cognitive tutor methodology, etc.), but every collaboration in the SAVI includes compelling questions of engagement. Engagement is a strategic nexus or intellectual core that all of our projects share. Across the partnerships, the study of learner engagement brings together multiple research frameworks and fields, including science and neuroscience, motivational research, social networks, learning technology, instruction and cultural context. **Engagement is a worthy center of gravity for the SAVI. When learning ecosystem designs succeed in immersing learners in contexts that involve academic tasks or challenges, virtuous cycles of self-regulation, growth in complex reasoning, discourse and argumentation, creativity, conceptual sophistication, and positive social dynamics can take form.** The SAVI involves eight sets of activities, including an active web presence, exchanges of early career and teacher researchers, a webinar series for researchers, educators and policy-makers, the development of research toolkits, virtual and in-person SAVI research meetings, short courses, and contributions to literature and research conferences in ways that reflect the SAVI's cross-disciplinary nature.

Table 1: The SAVI's eight initial projects.

Project Title	US Institutions	Finnish Institutions
1. Advancing an Online Project in the Assessment and Effective Teaching of Calculus	George Mason University, Florida State University, Texas A&M University,	University of Helsinki
2. Dynamic Digital Text: An Innovation in STEM Education	Auburn U., Un. of Wisconsin-Madison, Virginia Tech	University of Tampere, VATT, Aalto Univ., Turku
3. Engagement in STEM Learning and Teaching with Mobile Video Inquiries and Communities	Michigan State University	University of Helsinki
4. Expanding STEM Learning and Teaching with Mobile Video Inquiries and Communities	Stanford University, Pepperdine University	University of Helsinki, University of Lapland
5. FUN: A Finland-U.S. Network for Engagement and STEM Learning in Games	TERC, Northern Illinois University, WGBH	University of Tampare, Aalto University and University of Jyvaskyla
6. Global Cyber Tools for Improving	Boulder Learning	University of Jyvaskyla

Young Learners' Reading Comprehension, Scientific Discourse and STEM Learning	Technologies, Southern Methodist University, Pepperdine University	
7. Studying and Supporting Productive Disciplinary Engagement in Demanding STEM Learning	University of Washington, Oregon State University	Turku University
8. UNCODE-Uncovering Hidden Cognitive Demands on Global Learners	Stanford University	Aalto University, Finnish Institute of Occupational Health

Project activities appear in more detail at http://innovationsforlearning.net. In terms of brief overview this poster seeks to highlight core activities are each site and to sketch each project's contribution to the core questions of learner engagement. For example, in the first project (1), researchers from the U.S. and from Finland are conducting analyses on a massive open online course (MOOC) on calculus that is based at the University of Helsinki: the World Education Portals (WEPS). MOOCs represent a potentially revolutionary development in the design of teaching and learning environments.

In the Dynamic Digital Text project (2 above), the collaboration team carries out research on knowledge representation techniques for visualizing and presenting STEM content digitally in order to engage students and engender deep learning. The principal investigators are integrating the results of their research (in an iterative fashion) toward the development of new representation, interaction, and navigation techniques for digital STEM content, Content along with new navigation and automated assessment techniques are being developed and then classroom tested for college-level Computer Science and middle school-level Physics and Biology. In "Engagement in STEM Learning and Teaching with Mobile Video Inquiries and Communities" (3 above), researchers from the U.S. and Finland are collaborating to investigate how teachers use information about student engagement obtained through smart phone technology to make formative decisions regarding classroom instruction. Recognizing the importance of engagement for student achievement in science, these researchers are testing models to enhance engagement and its connection to teacher practices. The project carries out design-based research to establish a broadly scaleable approach for K-12 learners and teachers to capture mobile videorecordings of events and phenomena that spark questions for them that can serve as seeds for inquiries and collaborative learning in the STEM disciplines.

The "Expanding STEM Learning and Teaching with Mobile Video Inquiries and Communities" (4 above) project relies on the fact that the immense quantity of video resulting from digital videocameras everywhere is making video a potentially significant scientific medium for STEM educational purposes. Learning "how to see" scientific and mathematical aspects of real world phenomena and how to raise real questions that foster engagement in inquiries is a key education problem for the STEM disciplines. The "FUN: A Finland-U.S. Network for Engagement and STEM Learning in Games" project (5 above) blends methods and testbeds from both countries to get a broader picture of how engagement and learning are entwined in the growing field of game-based learning. Each team in this consortium is examining engagement in game-based learning in a different yet complementary way. The "Global Cyber Tools for Improving Young Learners' Reading Comprehension, Scientific Discourse and STEM Learning" project (6 above) collaboration takes advantage of a striking complementarity between the successfully piloted My Science Tutor (MyST) Project carried out by Boulder Language Technologies (BLT) and the successful and more widely-used Graphogame (GG) project based in Finland. The project takes the Graphogame pedagogy for learning foundational word reading skills, and embeds these skills in learning experiences that lead to fluent reading of science texts with deep comprehension using MyST technology.

The "Studying and Supporting Productive Disciplinary Engagement in Demanding STEM Learning" project (7 above) engages researchers to capitalize on innovative learning systems each has developed, where students take the role of practicing professionals (e.g., as an environmental scientist or a semiconductor pr! ocess engineer), and where they are encouraged to use the "language" and "practices" of the discipline to "get somewhere" (develop a product, improve a process, gain a better understanding of a phenomenon) over time. The collaborative partnership will allow the research team to better understand the nature of engagement in such complex STEM learning environments. The "UNCODE-Uncovering Hidden Cognitive Demands on Global Learners" project (8 above) connects researchers seeking to identify the stresses and cognitive demands that are placed on learners who are participating in multi-cultural and cross-disciplinary collaborations in a rich technology-enabled learning environment.

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