An Exploration based Pedagogical Framework to develop a MOOC on Nuclear and Radiochemistry

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Abstract. One of the outputs of MEET-CINCH project (A Modular European Education and Training Concept In Nuclear and radioCHemistry, Horizon 2020) is a MOOC on the applications of Nuclear and Radiochemistry with high societal impact, such as nuclear medicine, radiation technologies, environmental preservation, nuclear decommissioning and forensics.
This MOOC (online by the end of 2019) is characterized by an international dimension: it is the result of a collaboration among universities, research entities and institutions located in nine different European countries. Because of the variety and diversity of contributions, the design phase had to be preceded by an alignment about peculiarities of the target group; scientific level of contents and lexicon; methodology for designing, writing, sharing and reviewing the contents. The paper is intended to explain process and methodological choices, and difficulties encountered during the design phase due to the high number of partners, their different approaches in teaching, and the common mistrust towards nuclear issues by general public.

Keywords: Nuclear and Radiochemistry, Methodological approaches, International dimension, Pedagogical Framework

1 First Challenge: the international and multi-actors dimension

1.1 The project and the partnership

In 2010–2016 two "CINCH projects" (CINCH-I: Cooperation in Education in Nuclear Chemistry, and CINCH-II: Cooperation and training in Education in Nuclear Chemistry, supported within Euratom FP7) had been developed with the aim at mitigating the special skill-based deficits within nuclear chemistry at master and doctorate levels and the decline of number of staff qualified in this field.

MEET-CINCH [1] is the third project in the CINCH series, involves 12 partners from 9 EU countries including universities, research institutions and partners from industry [2], and aims at proactively bringing the results - achieved with the previous CINCH projects - so far to the end-users, at significantly contributing to attracting new talents and increasing the nuclear-chemistry awareness, and at investigating the applicability of some innovative pedagogical approaches in the nuclear-chemistry teaching and training field.

1.2 A MOOC on the applications of Nuclear and Radiochemistry

One of the main outputs of MEET-CINCH project is a MOOC that promotes the awareness about the usefulness of nuclear and radiochemistry (NRC). The partners, filling in the proposal form, identified some essential topics to demonstrate and high light how NRC is essential for our modern society and its development: decommissioning of nuclear plants, nuclear medicine, nuclear forensic and proliferation, tracer technology and industrial use of radionuclides, producing and handling nuclear fuel, creating new elements.

The designed approach is the result of an analysis of target and context and aims at attracting new students to study a discipline that has become fundamental for humans; designing a completely online path, able to involve students from different Bachelor degrees in science and different countries; presenting to the general public a discipline currently still often marginally known, that risks arousing fears related to environmental disasters or the illicit use of nuclear materials; guaranteeing the achievement of an effective and durable knowledge, necessary for a university choice and for a civic awareness.

However, at the beginning of the design phase led by Politecnico di Milano, although a full agreement was reached about objectives, themes and tools, partners realized to have very different ideas regarding how deep to explore contents, the use of a specialist and technical lexicon, the prerequisites and previous knowledge required to users, the teaching styles and tools, and the target-group needs. An alignment – not easy and not quick – has been also necessary about Massive Online Open Courses' terminology and characteristics, because only people from Politecnico di Milano had experience in MOOC designing and production.

The attempt was to guarantee the diversities and enlighten the specificities of everyone, concerning teaching style, but to weave a strong plot that would ensure formal and structural uniformity.

The difficulties due to different experiences and background, branches of research and approaches in teaching, but also objectives were partly overcome by giving the full responsibility of the process to a unique leading partner that supported colleagues in identifying learning objectives and in the drafting of the Table of Contents, reviewed every single content to ensure uniformity of lexicon and style and avoid repetition and is now managing the activities of recording and post-production of teaching materials.

1.3 The design process

After the identification of the target needs, the design team formulated teaching goals and learning objectives. This activity required a joint effort in finding a common definition of radiochemistry and identifying the main topics.

Didactical goals go back to the main issues of the project:

- to let users discover a largely unknown discipline, stimulating interest;
- to let users be aware of the possibility and the progress of this branch of science;
- to let users be able to make choices as citizens and explain their decisions and motivations;
- to help users developing a scientific attitude for applications of basic science;
- to stimulate users toward experimental activities and applications.

Specific learning objectives range from *understanding* to *remembering*, from *recognizing* to *be aware* and *be able to distinguish*, *catalogue*, *describe*, *list*, *compare*, *differentiate*.

A focus group was designed in order to collect information about students' preferences and attitude related to learning tools and channels, learning methodologies and approaches and has been proposed to some groups of students in Czech Republic, Finland, and Great Britain.

A specific Pedagogical Framework has been designed by Politecnico di Milano expert in methodologies to meet target-group needs, didactical goals and learning objectives; then a Table of Contents has been filled in, according to the logic of the application areas: Radiochemistry "for the environment", "for health", "for industry", "for nuclear energy", "for society", so that it could be easier for users to understand why NRC is useful, in which fields it is applied, which are the consequences of each application in terms of advantages and disadvantages.

Before going on in describing the challenges in designing and implementing the MOOC, it is interesting to focus on the focus group activity, the pedagogical framework and the prototype implementation.

MEET CINCH Focus Group. The activity has been structured according to the Flipped Classroom approach, with a phase to be hold by single students at home and two activities in classroom:

Table 1. Focus group phases.

AT HOME	IN SMALL GROUPS	ALL TOGHETER
Each student explores 4-5 learning resources and chooses which is his/her favorite and the best in terms of learning effectiveness	4-6 students discuss individual choices and select the best resources according to the following criteria: clarity, perceived learning effectiveness, engagement	Each group presents to the other ones the favorite resources and motivates its choice. At the end all the pupils vote and rank resources

The role of the school teachers during the Focus Group was to clearly explain the activity stages, the duration, the rules; to observe how the groups arrived at the result; to collect all the motivations provided by individuals and groups; to collect information about the use of mobile devices or laptops at home, about the real interest created by the activity, about any conditioning factors and, finally, to motivate students in giving their useful contribution to an European project.

The collected results gave a wide and broad overview. Beyond their personal tastes and previous knowledge level, the participants appreciated: the well-designed video explanations, in terms of number of concepts and alternation of theoretical parts, examples, cases, repetitions; animations, when and if they support and exemplify the explanation, proposing alternative points of view; music, if it does not distract and is not too prevalent on speaker voice; a good rhythm in speech, but not an excessive speed; the possibility to see real environments or laboratories; an average duration of 4-5 minutes.

From partner's perspective, the Focus group has been also an opportunity to experiment flipped classroom approach, engaging activities in the classroom, individuals' reflection about own learning, gamification.

MEET CINCH Pedagogical Framework. The Pedagogical Framework has been designed on the basis of the analysis of the context, the shared outcomes and the identified target, in order to lead teachers in organizing contents in single lessons. Thanks to an "immersion" in a typical everyday situation, at the beginning of each macro-theme, students can intuitively get the core concepts and then could complete their knowledge through systematic contents explanations, exercises, self-assessments, articles and links (see Fig. 1).

Fig. 1. MEET-CINCH MOOC Pedagogical Framework

Reflections of some well-known pedagogues have been a source of inspiration for the elaboration of this framework. Just to name a few, Jerome Bruner's "Discovery Learning" [3] suggested to start from current knowledge and awareness of learners, letting them select and transform information, construct hypotheses, and make decisions, because learning is an active process in which learners construct new ideas or concepts based upon their current/past knowledge. John Bigg's "Constructive Alignment" [4] has been a strong reference in supporting teachers in defining teaching goals, designing the learning path, aligning evaluation to learning objectives.

During the brainstorming phase, the need to attract and involve people constantly emerged among partners, but also the wish to tell stories: not only environmental disasters, but daily stories of solved troubles, effective treatment, management and monitoring of air, water, soil for the collective well-being.

The Video-Prototype. With the implementation of a prototype, some doubts and difficulties - regarding possible outcome - have been resolved. The prototype has been developed on the introductory topic: "The natural radioactivity and the radiochemistry". To create it, Politecnico di Milano experts have prepared a storyboard and, thanks to a continuous and intense dialogue among teachers, visual and instructional designers, the prototype video has been recorded, produced and shared.

Fig. 2. Three sequences from the Video-Prototype

2 Second Challenge: the engagement of the target-group(s)

2.1 Bachelor Students

Partners needed not few debating meetings to agree about target group at the beginning of the design phase. The target audience selected for the MOOC on NRC is "Bachelor students in chemistry/physics/engineering/other scientific areas with a background knowledge deriving from high school and higher education, in particular in Chemistry, Physics and Math; supposed to have availability of free time and flexibility and to be used to studying with web tools; being keen on increasing the knowledge about nuclear themes and their applications, as possible university career and job opportunity".

2.2 General Public

As that the Nuclear field is often source of perplexity or fear, MEET-CINCH partners oriented the whole project to the general public, aiming at providing the basic information for an active political life as citizens. Taking into account these issues, they decided to design some lessons of MOOC for non-experts, with the specific scope of offering an opportunity to discover some issues related to energy production, nuclear waste management, diagnosis and treatment of diseases, and all those activities that have become essential in the life of humans of twenty-first century, but which are still often marginally known.

2.3 Two levels

A learning path must have a primary target audience: this is the only way to guarantee the user can understand, be engaged and achieve the planned outcomes. MEET-CINCH MOOC is designed for Bachelor students, but some lessons are labelled as "popular-scientific" ones, so that some lessons for each topic explained could be enjoyed by a general public. The MOOC is organized in the typical structure of weeks, modules and lessons. The first Lesson of each week or, in some cases, of each module is a daily situation: according to the Pedagogical Framework, users watch some characters who sit at a bar table, go down to the garage to get the car, eat a banana, buy fertilizer for plants, and so on (see Fig. 3).

Fig. 3. Two sequences from “Diving” - Lessons 1

In Lesson 2 an expert explains why all these activities deal with radioactivity.

In Lesson 3 a teacher introduces the specific topic.

From Lesson 4 of each Module the level of scientific knowledge becomes higher, the lexicon is more specific, the notions become more complex.

3 Conclusion

MEET CINCH MOOC is under construction: teachers from different universities and research bodies are well engaged and soon will converge to Politecnico to record their lessons.

The next challenge will be to take the MOOC out of the university "classrooms" and to get it to the general public: our responsibility is to shape the future in building a civic awareness, so that every citizen could choose independently about his own and future generations’ life.

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