Gender gap perception of computer science students in Costa Rica: a case study in two public universities

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Abstract

Gender equality is among the objectives of governments, companies, public institutions and other different entities. There are various challenges related to the gender gap that affect different parts of society. In particular, the gender gap associated with the technology sector is a well-known problem for which organizations are looking for solutions. It starts in primary education and continues into the professional field. The number of women who start and finish higher education programs related to computer science and informatics shows alarming figures in most countries and regions worldwide. In Costa Rica, the number of women enrolled in these programs in 2017 was around 20% despite the fact that this country is well ranked in the Global Gender Gap Index, both globally and in the Latin America and the Caribbean region. This study aims to analyze the perception of computing students concerning the gender gap in computer science studies in two public universities in Costa Rica. We applied a validated instrument that identifies computer engineering students' perceptions of gender and diversity issues divided into three dimensions: academic perception, social perception and professional competence. The results indicate the gender influences in most of the items related to academic perception and people who experienced discrimination, themselves or a relative, are more sensitive to the inequalities (N=228).

Keywords

Gender gap, computer science, higher education, students' opinion, Costa Rica.

1. Introduction

The gender gap is a well-known problem associated with the technology sector, emphasizing the number of women who start and finish higher education programs related to computer science and informatics.

In the context of Costa Rican public universities, some studies [1-3] have confirmed essential differences between men and women in their participation in computer science tertiary studies [4]. The State of Costa Rican Education Report [5] published in 2019 highlights the gender gap in computer science programs enrollment. In particular, based on 2017 figures, the number of women enrolled in these programs is around 20%.

According to the Global Gender Gap Index ranking [6], Costa Rica is in the second position in the Latin America and the Caribbean region and the fifteen in the global ranking with a score of 0.786. Although the parity has achieved in the enrolment in tertiary education [7], there is a significant gap in the percentage of male/female graduates from Information and Communication Technologies (ICT) programs. Specifically, 13,5% of graduates from higher education programs are in ICT studies. However, of that percentage, only 13.7% are female compared to 86.3% male [6].

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In this context, the European project W-STEM (Building the future of Latin America: engaging women into STEM) [8-10] is focused on developing concrete actions to modernize the government, management and operation of higher education institutions in Latin America to improve women's access to STEM (Science, Technology, Engineering and Mathematics) programs. In particular, Costa Rica is involved in the project through two institutions: the University of Costa Rica (UCR) and the Costa Rica Institute of Technology (TEC). The actions of the project are aimed to improve the mechanisms before the university studies (attraction), when women try to enroll in STEM programs (access) and during the STEM studies (guidance and retention).

This work is a case study in Costa Rica focused on students already enrolled in technology studies (the T of STEM) to analyze their perception concerning the gender gap in computer science and informatics studies. The results will be used to improve the mechanisms of attraction, access and guidance. The study uses the GENCE 2.0 questionnaire (GENder perspective in the Computer Engineering questionnaire) [11]. In particular, we answer the following questions: 1) does the perception of the gender gap in technology depend on gender?; 2) does the perception of the gender gap in technology depend on whether the person or someone in his or her environment has suffered discrimination?

The rest of the document is organized as follows. Section 2 describes the details of the methodology. Section 3 presents the comparative analysis and main results. Section 4 describes the discussion of the results. Finally, the last section summarizes the main conclusions of the study.

2. Methodology

2.1. Participants

The population of this study is students from Computer Science programs from two Costa Rican universities, the Costa Rica Institute of Technology and the University of Costa Rica. These institutions are two of the top public universities in Costa Rica.

The University of Costa Rica is a public institution of higher education, founded in 1940 and declared a Meritorious Institution of Costa Rican Education and Culture. The students who answered the questionnaire correspond to the Bachelor's Degree in Computer Science with Various Specializations (Computer Science, Software Engineering, and Information Technology Engineering), offered by the School of Computer Science and Informatics. This program is an undergraduate program and consists of a four-year curriculum, two of them for a common core and the remaining two for emphasis or specialization courses.

Regarding the Costa Rica Institute of Technology, it was founded in 1971 and it is oriented to the modernization and improvement of the national productive sector and technology transfer for the transformation of the Costa Rican society. The students involved in the study are enrolled in Bachelor's Degree in Information Technology Management and Bachelor's Degree in Computer Engineering offered by the School of Computer Science.

2.2. Instrument

We used the GENCE 2.0 (GENder perspective in Computer Engineering questionnaire, version 2.0) [11] adapted to the Costa Rican higher education context. The primary purpose of this instrument is to identify computer engineering students' perceptions of gender and diversity issues [12]. The instrument has three different sections:

- 10 questions to collect demographic information: university, highest course enrolled, gender, age, sexual orientation, family unit and data from the person who contributes the most income to the family unit.
- 12 questions adapted from previous works [20, 21] related to the decisions made and the support received before enrolling in the computer studies.
- 20 Likert items which compose the core part of the instrument. These items cover three dimensions related to gender differences in the computing sector. The Likert scale

expresses agreement (1=Strongly disagree, 2=disagree, 3=undecided, 4=agree, 5=strongly agree). Table 1 presents the items which are part of each dimension.

Table 1
Likert items of GENCE 2.0 to measure the perception of the gender gap in computing

Social perception (8 items)		Professional competence (5 items)		Academic perception (7 items)	
Q15	All people must have the same rights regardless of gender.	Q18	The women who make studies in Computer Engineering are not feminine enough.	Q13	Computer Engineering students are treated differently by their teachers according to their gender.
Q16	Gender equality is an important issue that must be addressed from all spheres (family, education, social, and work).	Q20	Women have more problems than men when programming.	Q14	People who enroll in Computer Engineering studies receive the same institutional support regardless of gender.
Q19	People who study Computer Engineering are considered "freaks" (rare).	Q21	Gender influences the fulfillment of Computer Engineering studies.	Q17	Gender equality must be part of the University's curricula.
Q28	There is a need for more women to work in the technology sector.	Q25	Men are better prepared than women to work in the informatics sector.	Q22	Men and women have the same opportunities to study engineering careers, such as Computer Engineering.
Q29	The gender gap is a fad.	Q26	Nowadays, women have more problems than men in finding a job in the technology sector.	Q23	People in Computer Engineering studies treat their peers of another gender in the same way.
Q30	The gender gap is not a problem that must be addressed as part of Computer Engineering studies.			Q24	The professors in Computer Engineering studies treat all students equally regardless of gender.
Q31	People working in the technology sector must help reduce the gender gap in their sector.			Q27	Nowadays, men and women receive the same remuneration for similar positions.
Q32	The gender gap is a problem that only affects women.				

Red items are not considered in this study

2.3. Data collection

The questionnaire was shared in both institutions in May 2021. Each institution sent an email to the students from computer science and informatics programs. The data was collected using LimeSurvey with the anonymous option enabled to ensure the participants' privacy. The students voluntarily participated in this study and decided whether to complete the questionnaire.

Regarding data analysis, the answers were downloaded in Excel format and processed using SPSS Statistics 25 (License of the University of Salamanca Campus). It should be considered that items Q13, Q18, Q19, Q20, Q21, Q25, Q27, Q29, Q30 and Q32 were inverted so that all items have the same scale.

We used Cronbach's alpha coefficient to measure the internal consistency of the instrument. Items Q26, Q27, Q28, Q29, Q30 and Q32 were removed due to negative item-total correlations (red items in Table 1). The Cronbach's alpha coefficient is 0.704 [13].

2.4. Sample

The sample comprises 228 valid responses, 131 from the Costa Rica Institute of Technology (60.09%) and 87 from the University of Costa Rica (39.91%). Regarding gender, 31.2% are women, 65.6% are men, 3.2% preferred not to answer. Table 2 summarizes the main characteristics of the sample. According to the statistics, the percentage of women in the sample is higher than the average of women in computer science studies in Costa Rica [5].

Table 2
Distribution of the sample per institution, gender, age, discrimination, support received to start the computer studies and consider drop-out computer studies

Variables	Total (N=228)	TEC (N=135)	UCR (N=93)
Gender			
Women	72 (31.6%)	41 (30.4%)	31 (33.3%)
Men	149 (65.4%)	90 (66.7%)	59 (63.4%)
Preferred not to answer	7 (3.1%)	4 (3%)	3 (3.2%)
Age			
Less than 20 years old	103 (45.2%)	67 (49.6%)	36 (38.7%)
Between 21 and 25	87 (38.2%)	40 (29.6%)	47 (50.5%)
Between 26 and 30	21 (9.2%)	16 (11.9%)	5 (5.4%)
Between 31 and 35	9 (3.9%)	7 (5.2%)	2 (2.2%)
Between 36 and 40	3 (1.3%)	1 (.7%)	2 (2.2%)
More than 40 years old	5 (2.2%)	4 (3%)	1 (1.1%)
Sexual orientation			
Heterosexual	156 (68.4%)	101 (74.8%)	55 (59.1%)
Lesbian, gay or homosexual	15 (6.6%)	8 (5.9%)	7 (7.5%)
Bisexual	41 (18%)	19 (14.1%)	22 (23.7%)
Something different	6 (2.6%)	3 (2.2%)	3 (3.2%)
I do not know	9 (3.9%)	4 (3.0%)	5 (5.4%)
I refuse to answer	1 (0.4%)		1 (1.1%)
Discrimination [a]			
Yes	89 (39%)	46 (34.1%)	43 (46.2%)
No	139 (61%)	89 (65.9%)	50 (53.8%)
Support received [b]			
Nobody	32 (14%)	22 (16.3%)	10 (10.8%)
Father	72 (31.6%)	42 (31.1%)	30 (32.3%)
Mother	39 (17.1%)	19 (14.1%)	20 (21.5%)
Other relatives	54 (23.7%)	31 (23.0%)	23 (24.7%)
A friend	11 (4.8%)	6 (4.4%)	5 (5.4%)
A teacher	12 (5.3%)	8 (5.9%)	4 (4.3%)
Other	8 (3.5%)	7 (5.2%)	1 (1.1%)
Drop-out computing studies [c]			
Yes	99 (43.4%)	50 (37%)	49 (52.7%)
No	129 (56.6%)	85 (63%)	44 (47.3%)

[a] Have you or someone in your environment (family, friends, school, etc.) ever been discriminated against because of belonging to a particular group (men, women, people of other sexual orientations, ethnicity, etc.)?
[b] Who supported you to start your computer studies?
[c] Have you ever considered dropping out of computer studies?

3. Results and analysis

Table 3 shows the descriptive statistics obtained during the data collection. We analyzed data collected in each higher education institution as a unique sample, although we have compared the results obtained in each university. The descriptive analysis grouped by institution does not provide visible differences and the statistic test confirms this result. However, we have tested a hypothesis to establish if the gender or the discrimination variable influences students' perception of the gender gap in technology studies.

First, it is necessary to identify which statistics tests are necessary to perform hypothesis contrasting. The normality test results (Table 4) rejects the null hypothesis of normal population distribution ($p<.05$); the data is not normally distributed. Therefore, non-parametric tests are used to perform hypothesis contrasting, first regarding gender and second regarding discrimination.

Table 3
Results of the descriptive analysis (N=228)

	md	sx		md	sx
Q13_R	3.3289	1.31130	**Q20_R**	4.4605	.94948
Q14	4.00	1.284	**Q21_R**	4.1053	1.22290
Q15	4.90	.505	**Q22**	3.83	1.308
Q16	4.71	.798	**Q23**	3.43	1.307
Q17	3.79	1.406	**Q24**	3.62	1.279
Q18_R	4.6316	.74813	**Q25_R**	4.5526	.88643
Q19_R	2.9605	1.31183	**Q31**	4.28	1.023

sx = sample standard deviation
md = mean score

Table 4
Normality test results (N=228)

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistics	**df**	**Sig.**	**Statistics**	**df**	**Sig.**
Q13_R	.162	228	.000	.891	228	.000
Q14	.300	228	.000	.762	228	.000
Q15	.523	228	.000	.189	228	.000
Q16	.490	228	.000	.409	228	.000
Q17	.298	228	.000	.790	228	.000
Q18_R	.443	228	.000	.556	228	.000
Q19_R	.180	228	.000	.893	228	.000
Q20_R	.421	228	.000	.622	228	.000
Q21_R	.342	228	.000	.737	228	.000
Q22	.249	228	.000	.810	228	.000
Q23	.209	228	.000	.883	228	.000
Q24	.208	228	.000	.864	228	.000
Q25_R	.439	228	.000	.571	228	.000
Q31	.339	228	.000	.725	228	.000

First, we conduct the analysis to reject or accept the null hypothesis "The gender does not influence in the perception of the students about the gender gap in technology". Gender is a variable with three options, woman, man and prefer not to answer. For this reason, significant differences are detected using the Kruskal-Wallis test. The results (Table 5) show statistical differences in half of the items, Q13_R, Q16, Q17, Q22, Q23, Q24 and Q31 for $p<0.5$. Most of the differences are located in the academic perception dimension (Figure 1).

Based on these results, we further apply the Mann-Whitney U test for analyzing if the differences depend on the institution. There are differences between women in the Q15, Q17, Q22 and Q31 items regarding the intersection between gender and institution. Meanwhile, there are no significant differences among men from both institutions, only in the Q17 item.

Table 5

Kruskal-Wallis results for gender (woman, man, prefer not to answer) and Mann-Whitney U results for suffering from or being in close to situations of discrimination (yes, no) (N=228)

	Gender			Discrimination		
	H	**gl**	**Sig**	**U**	**Z**	**Sig**
Q13_R	9.696	2	**.008**	4065.00	-4.478	**.000**
Q14	1.668	2	.434	5194.50	-2.211	**.027**
Q15	.861	2	.650	5875.50	-1.649	.099
Q16	7.321	2	**.026**	5315.50	-2.891	**.004**
Q17	6.762	2	**.034**	4089.50	-4.621	**.000**
Q18_R	2.641	2	.267	5860.00	-.890	.374
Q19_R	.151	2	.927	4662.00	-3.222	**.001**
Q20_R	3.935	2	.140	6090.00	-.245	.806
Q21_R	4.683	2	**.096**	4862.50	-3.038	**.002**
Q22	11.807	2	**.003**	4176.50	-4.358	**.000**
Q23	22.512	2	**.000**	4152.00	-4.299	**.000**
Q24	9.105	2	**.011**	4229.50	-4.161	**.000**
Q25_R	.395	2	.821	6106.00	-.214	.830
Q31	19.777	2	**.000**	4632.00	-3.589	**.000**

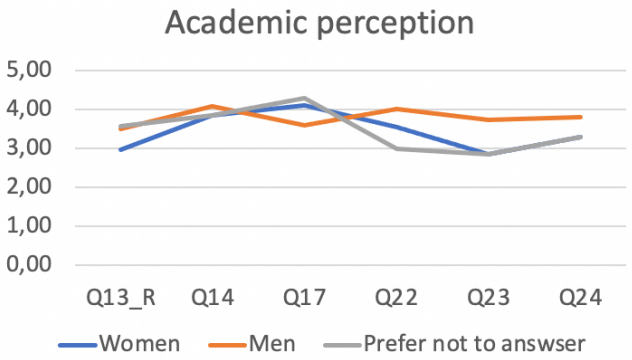

Figure 1: Average scores of the students per gender in the academic perception dimension (Women N=72, Men N=149, Prefer not to answer N=7)

On the other hand, we conduct the analysis to reject or accept the second null hypothesis "The experiences related to discrimination do not influence the students' perception about the gender gap in technology". To answer the second research question, we compare if there are differences among women and men who have suffered or were close to a situation of discrimination. The descriptive analysis regarding discrimination (Table 6) shows visible differences between people who answer the question, "Have you or someone in your environment (family, friends, school, etc.) ever been discriminated against because of belonging to a particular group (men, women, people of other sexual orientations, ethnicity, etc.)?", whereas it is necessary to perform hypothesis contrasting to confirm it.

The Mann-Whitney U test identifies significant differences for most of the items for $p<0.5$. All items except Q15, Q18_R, Q20 and Q25_R reject the second null hypothesis; therefore, the experiences related to discrimination influence the students' perception of the gender gap in technology. Furthermore, we corroborate differences in the same items between people who suffered discrimination regardless of gender. Specifically, we apply the Mann-Whitney U test in subsets of the sample

composed of the responses from the same gender in order to analyze if the differences also depend on the gender.

Table 6
Results of the descriptive analysis of the items according to discrimination variable

	Yes (N=89)		No (N=139)	
	md	**sx**	**md**	**sx**
Q13_R	2.8427	1.27831	3.6403	1.23949
Q14	3.76	1.374	4.15	1.203
Q15	4.98	.149	4.86	.632
Q16	4.92	.310	4.58	.970
Q17	4.30	1.181	3.45	1.441
Q18_R	4.6742	.73508	4.6043	.75775
Q19_R	2.6292	1.30019	3.1727	1.27931
Q20_R	4.4607	.98922	4.4604	.92678
Q21_R	3.7978	1.34147	4.3022	1.10108
Q22	3.38	1.336	4.12	1.210
Q23	2.94	1.360	3.73	1.177
Q24	3.16	1.373	3.92	1.123
Q25_R	4.5618	.90397	4.5468	.87826
Q31	4.54	.867	4.11	1.081

sx = sample standard deviation
md = mean score

The experiences related to discrimination mainly influence two of the three dimensions of the instrument. Figures 2, 3 and 4 summarize the average scores regarding discrimination per dimension (Social perception, Professional competence and Academic perception).

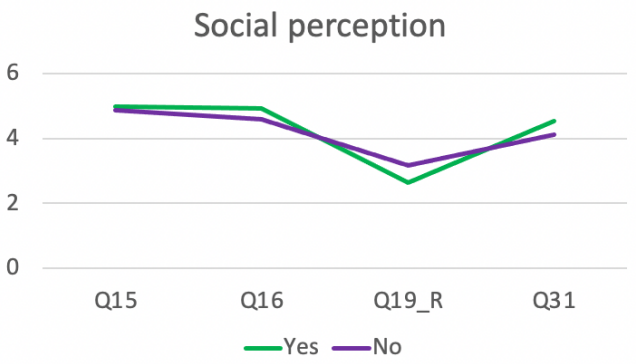

Figure 2: Average scores of the students per discrimination response in the social perception dimension (Yes N=89, No N=129)

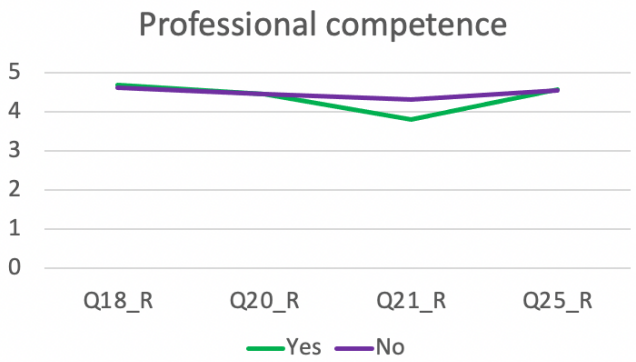

Figure 3: Average scores of the students per discrimination response in the professional competence dimension

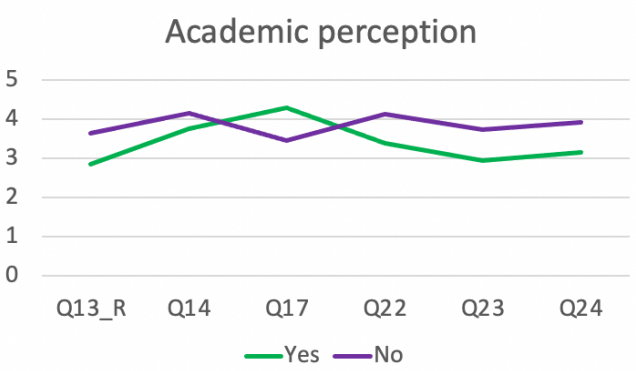

Figure 4: Average scores of the students per discrimination response in the academic perception dimension

4. Discussion

First, it is crucial to clarify the lack of differences between the results collected in each institution at the general level. This result could be explained because TEC and UCR are located in the same region and both are public universities, so their students could have the same characteristics related to socio-cultural and economic distribution.

This work aims to answer two research questions related to which variables could influence the students' perception of the gender gap in technology. First, we analyze the data collected to get information about the impact of gender, "does the perception of the gender gap in technology depend on gender?". The results indicate the gender influences in most of the items related to academic perception (Figure 1). Women are less agreed than men concerning equal opportunities to study engineering careers, such as Computer Engineering (Q22). Also, women perceive that both students (Q23) and professors (Q24) in Computer Science studies do not always treat their peers/students equally regardless of gender. Furthermore, women are more agreed than men with the statement "Gender equality must be part of the University's curricula" (Q17). This pattern is repeated in other opinions related to the academic context; women perceive less gender equality in the academic context than men.

The results have also shown that the institution does not influence the perception of the students. Men from both institutions agree in all items except Q17; men from TEC are less agree than men from UCR about including gender equality as part of the University's curricula. This situation is replicated if we analyze the women's results per institution, women from UCR are more in agreement than women from TEC.

Concerning the second research question, "does the perception of the gender gap in technology depend on whether the person or someone in his or her environment has suffered discrimination?", 39.33% of the people who answer yes regarding discrimination are women, and 55.06% are men (N=89). If we analyze the percentages considering the total number of women and men, we found that

48.6% of female participants had experienced discrimination (N=72), compared to 32.9% of male participants (N=149) and 71.4% who preferred not to indicate the gender (N=7). Figures 2, 3 and 4 summarizes the main results. People who experienced discrimination, themselves or a relative, are more sensitive to the inequalities, according to the results. In particular, they strongly agree that gender equality is an important issue that must be addressed from all spheres (Q16) and people working in the technology sector must help reduce the gender gap in their sector (Q31).

However, all students, independently of the discrimination, strongly agreed that "All people must have the same rights regardless of gender". This result is similar to a previous study carried out in Argentina and Peru [14], even though in Peru the agreement is a bit lower than in Costa Rica and Argentina.

Regarding professional competence, no significant differences are observed in terms of professional perception concerning the discrimination variable. Finally, people who have experienced any type of discrimination (Figure 4) have similar opinions and perceptions than women (Figure 1) in the academic perception dimension. Likewise, men have similar opinions than people who have not experienced discrimination.

5. Conclusions

The study analyzes students' perception regarding the gender gap in computer science and informatics studies in two public universities in Costa Rica. The analysis is focused on answering two questions to reject or accept if gender or previous experiences related to discrimination can influence the opinions related to the gender gap in technology.

The results confirm that both variables impact the opinions and perceptions of the students involved in the study. However, caution must be applied because of the sample size, as the findings might not be transferable to all computer science and informatics students in Costa Rica. On the other hand, although the original version of GENCE 2.0 includes a non-binary option, it is challenging to get conclusions about non-binary people due to the percentage of people who identify with this option.

The data collected provides interesting results to go deeper in future studies. Other institutions across Costa Rica should be included to check whether the conclusions obtained extend to the whole population. Furthermore, parallel studies will be conducted in other countries, with a particular focus on Latin America and Europe as part of the activities associated with the European project W-STEM (https://wstemproject.eu).

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