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Gender gap perceptions of computing students: a case study in two Spanish universities

Alicia García Holgado
GRIAL Research Group
Computer Science Department
Univeresity of Salamanca
Salamanca, Spain
aliciagh@usal.es

Carina S. González-González
University Institute of Women's Studies (IUEM)
University of La Laguna
La Laguna, Spain
cjgonza@ull.edu.es

Francisco José García-Peñalvo
GRIAL Research Group
Computer Science Department
Univeresity of Salamanca
Salamanca, Spain
line 5: email address or ORCID

***Abstract*— Reducing the gender gap is one of the main challenges that society is facing. Equality, not only of women but of different gender identities, is one of the European Union's priorities, as well as of a large part of the developed countries. In particular, in science, technology, engineering and mathematics (STEM), the gender gap is visible both in the academic and professional fields. In higher education, according to the Women in Digital Scoreboard, in Europe, only 17% of ICT specialists are women. This figure is lower in Spain, with only 16%. According to the Ministry of Education in Spain, the percentage of women in computer science studies in 2018-2019 was 12.93%. This study aims to analyze the perception of computing students concerning the gender gap in computer science studies. In particular, the study was carried out in two Spanish universities located in different regions (N=95).**

Keywords—gender gap, quantitative study, computer science, higher education.

I. INTRODUCTION

In a formally gender-equal society, one of the main problems associated with gender inequality is making it visible. This problem is still present among young people and societies that have overcome almost all formal inequalities [1]. For this reason, it is essential to make visible and unfair gender inequality from an early age. The promotion of diversity at all levels of education is one of the measures to be carried out by entities and governments. In particular, in the STEM sectors (Science, Technology, Engineering, and Mathematics) significant inequalities have been identified for equitable representation [2-10].

The gender gap in STEM has historically been associated with differences in mathematical performance between boys and girls, according to the results of PISA reports [11]. Although many of the professions in STEM have a high mathematical component, studies have shown that girls perform better than boys in countries with greater gender equality [12-14]. Despite this, countries such as Norway, Finland and Sweden, which are among the most egalitarian societies in the world according to the latest World Economic Forum index [15], have one of the largest gender gaps in STEM studies [16].

There are different approaches to face the gender gap in these areas. There are actions at all educational stages and also in the professional context [17, 18]. Organizations, companies, public entities, are focused on reducing the gender gap in STEM. Despite this, research related to the gender gap focuses mostly on the pre-university stage and the professional stage by addressing the university stage, usually focusing on the drop-out of under-represented groups such as women [19]. Within this framework, the authors of this paper focus on the university stage in order to achieve an impact on future professionals in the STEM sector by focusing on the technological field. STEM graduates, and in particular computer engineering graduates, must be aware of the gender gap in their professional field, enabling them to implement future actions to reduce it and achieve inclusive and diverse working environments.

In this context, the GENder perspective in the Computer Engineering questionnaire (GENCE) aims to identify the perception of computing students about issues related to gender and diversity [20]. This work presents a case study conducted in two public universities in Spain to analyse the perception of the computing students using GENCE 2.0, the last validated version of the instrument. In particular, the instrument was applied at the University of La Laguna and the University of Salamanca.

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.

II. METHODOLOGY

A. Participants

The population of this study is computing students in two Spanish universities, the University of Salamanca and the University of La Laguna. These institutions are in different regions of Spain, one located in the peninsula and another in the Canary Islands.

In particular, the computing students that compose the population are enrolled in the degree of Computer Engineering. The study was conducted in the "Human-Computer Interaction Systems" subject offered on the first semester of the third year of the degree at ULL; and the "Software Engineering I" subject offered on the second semester of the second year of the degree at USAL.

B. Instrument

We use the GENCE 2.0 (GENder perspective in Computer Engineering questionnaire, version 2.0) [20]. The main purpose of this instrument is to identify computer engineering students' perceptions of gender and diversity issues.

GENCE 2.0 is a validated instrument composed of three sections. First, twelve questions to get the background of the participant such as the decisions made and the support received before enrolling in the university. These questions were a combination of tailor-made items and an adaptation of previous works [21, 22].

Second, nine demographic questions (Highest course enrolled, gender -avoiding binary bias -, age, sexual orientation, family unit, the person who contributes the most income to the family unit – plus his/her highest level of

education, his/her employment situation, and his/her occupation according to the ten main groups of ISCO-08).

Finally, twenty five-level Likert items about the perception of the students about the gender differences in the social, professional and academic dimension in the computing sector (Table I). The Likert scale express agreement (1=Strongly agree, 2=agree, 3=undecided, 4=disagree, 5=strongly disagree).

TABLE I. LIKERT ITEMS ORGANIZED IN DIMENSIONS

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.				

C. Data collection

The questionnaire was applied in both institutions in the 2019-2020 academic year. In particular, we used a customized version of LimeSurvey to collect the data and ensure secure access to the information. The students voluntarily participated in this study and decided whether to complete the questionnaire. Anonymity was guaranteed.

Regarding data analysis, the answers were downloaded in Excel format and imported into SPSS Statistics 25 (License of the University of Salamanca Campus) to conduct the statistics test. 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.

Cronbach's α coefficient using the data gathered from both institutions is 0.923, so the internal consistency of the instrument is over the recommended value of 0.7.

D. Sample

The sample is composed of 95 valid responses, 40 from the University of La Laguna (42.1%) and 55 from the University of Salamanca (57.9%). Regarding the gender distribution, 23 women (24.2%), 67 men (70.5%), 1 non-binary (1.1%) and 4 prefer not to indicate (4.2%). The representation of women in the sample is higher than the average of women in computing studies in Spain, according to the official statistics[1].

III. RESULTS AND ANALYSIS

Regarding the analysis of the results, as a first step we have calculated the descriptive statistics of the students' responses grouped by data collection (Table II). The average of almost all items is between 1 (fully agree) and 2 (agree), but there are visible differences between the institutions. We use a hypothesis contrast to determine if the results depend on the institution or other variables such as gender.

Both the Kolmogorov-Smirnov test and the Shapiro-Wilk test results suggest that the items do not follow a normal distribution (Table III). Therefore, a non-parametric test should be used to perform hypothesis contrasting.

TABLE II. RESULTS OF THE DESCRIPTIVE ANALYSIS OF THE ITEMS ACCORDING TO UNIVERSITY (N=95)

	ULL			**USAL**		
	md	**sx**	**N**	**md**	**sx**	**N**
Q13	1,98	1,097	40	1,95	1,079	55
Q14	1,63	1,079	40	2,16	1,371	55
Q15	1,15	,662	40	1,38	1,027	55
Q16	1,45	,783	40	1,73	1,209	55
Q17	2,70	1,539	40	2,42	1,449	55
Q18	1,45	,904	40	1,93	1,168	55
Q19	3,28	1,198	40	3,25	1,205	55
Q20	1,28	,784	40	1,64	1,161	55
Q21	1,70	1,159	40	1,69	1,169	55
Q22	1,98	1,310	40	1,73	1,062	55
Q23	2,22	1,271	40	2,09	1,191	55
Q24	2,07	1,118	40	2,02	1,209	55
Q25	1,40	,955	40	1,76	1,217	55
Q26	3,10	1,297	40	3,42	1,182	55
Q27	2,80	1,224	40	3,11	1,197	55
Q28	2,22	1,271	40	2,58	1,117	55
Q29	2,05	1,319	40	2,76	1,347	55
Q30	2,85	1,494	40	3,16	1,411	55
Q31	2,23	1,441	40	2,53	1,317	55
Q32	2,02	1,230	40	2,62	1,254	55

[1] http://estadisticas.mecd.gob.es/EducaDynPx/educabase/index.htm?type=pcaxis&path=/Universitaria/Alumnado/1GradoCiclo/Matriculados/

TABLE III. TESTING FOR NORMALITY RESULTS

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistics	**df**	**Sig**	**Statistics**	**df**	**Sig**
Q13	,244	95	,000	,807	95	,000
Q14	,305	95	,000	,735	95	,000
Q15	,509	95	,000	,354	95	,000
Q16	,382	95	,000	,635	95	,000
Q17	,199	95	,000	,836	95	,000
Q18	,369	95	,000	,700	95	,000
Q19	,215	95	,000	,895	95	,000
Q20	,439	95	,000	,531	95	,000
Q21	,389	95	,000	,651	95	,000
Q22	,329	95	,000	,722	95	,000
Q23	,237	95	,000	,832	95	,000
Q24	,251	95	,000	,807	95	,000
Q25	,412	95	,000	,604	95	,000
Q26	,202	95	,000	,895	95	,000
Q27	,190	95	,000	,904	95	,000
Q28	,199	95	,000	,866	95	,000
Q29	,200	95	,000	,857	95	,000
Q30	,155	95	,000	,879	95	,000
Q31	,204	95	,000	,845	95	,000
Q32	,217	95	,000	,859	95	,000

First, we analyze if there are significant differences between both institutions. According to the results of the Mann-Whitney U test, the null hypothesis is rejected in five items (Table IV). The statistical differences between institutions are in the items Q14, Q18, Q20, Q29 and Q32 since the level of significance is less than 0.07.

Also, we conduct several hypotheses contrasts to identify differences regarding a set of nominal variables: gender, family unit, support received before starting the computer engineering studies and the discrimination, either the person or someone in his/her family discrimination.

Regarding gender, the analysis compared only binary options due to the low number of answers in the categories "non-binary" (1 student) and "prefer not to indicate (4 students). The results show that there are no significant differences in most of the items between women and men (Table IV). Only there are differences between women and men in Q15, Q17, Q18, Q28 and Q32. Furthermore, if we analyze the differences between the combination of gender and university, similar results are obtained using the Kruskal-Wallis non-parametric test. Items Q17, Q28, Q29 and Q32 show significant differences.

Regarding the family unit, there are no significant differences for most of the items. Only item Q20 and Q32 have significant differences regarding taking into account two categories to analyze the family unit impact. A nuclear family that corresponds with 71 students (74.7%); and other types of family – single parent, LGBT parenting, composite family, extended family – with 22 students in this category (23.2%).

Similar results are obtained for the variable support received before starting the degree. According to the Mann-Whitney U, only items Q15 and Q26 show differences in the perception of the students about the gender gap in computing. In this case, the support variable was clustered into two categories, students who did not receive support (43.2%) and students who receive support (56.8%).

Finally, the most significant differences are related to the discrimination variable. It is a dichotomous variable (yes, no) that collect the answer to 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.)?". The hypothesis contrast shows that 12 of 20 items have significant differences depending on this variable (Q13, Q16, Q17, Q23, Q24, Q26, Q27, Q28, Q29, Q30, Q31, Q32).

TABLE IV. MANN-WHITNEY U RESULTS FOR THE VARIABLE UNIVERSITY, GENDER AND DISCRIMINATION; AND KRUSKAL-WALLIS RESULTS FOR GENDER COMBINED WITH UNIVERSITY

	University (N=95)			Gender (N=90)			University&Gender (N=90)			Discrimination (N=95)		
	U	**Z**	**Sig**	**U**	**Z**	**Sig**	**H**	**gl**	**Sig**	**U**	**Z**	**Sig**
Q13	1086,000	-,112	,911	756,500	-,138	,890	1,132	3	,769	525,500	-3,580	**,000**
Q14	847,000	-2,089	**,037**	711,000	-,608	,543	5,569	3	,135	905,500	-,291	,771
Q15	1018,000	-1,113	,266	655,500	-1,950	**,051**	4,232	3	,238	827,500	-1,624	,104
Q16	1008,000	-,828	,408	630,500	-1,550	,121	3,281	3	,350	748,000	-1,851	**,064**
Q17	992,000	-,841	,400	508,000	-2,512	**,012**	7,515	3	**,057**	566,000	-3,137	**,002**
Q18	840,500	-2,254	**,024**	589,500	-1,915	**,055**	6,438	3	,092	902,500	-,334	,738
Q19	1086,500	-,105	,916	750,500	-,191	,848	1,206	3	,752	902,000	-,304	,761
Q20	919,500	-1,814	**,070**	729,500	-,504	,614	2,397	3	,494	789,000	-1,621	,105
Q21	1093,000	-,063	,950	682,500	-,973	,331	1,979	3	,577	900,000	-,370	,712
Q22	1003,000	-,815	,415	724,000	-,482	,630	1,230	3	,746	861,000	-,700	,484
Q23	1041,500	-,463	,644	591,000	-1,747	,081	3,143	3	,370	730,000	-1,781	**,075**
Q24	1032,000	-,542	,588	715,500	-,540	,589	4,327	3	,228	655,500	-2,440	**,015**
Q25	914,000	-1,743	,081	728,500	-,480	,631	2,068	3	,559	806,000	-1,340	,180
Q26	946,000	-1,202	,229	621,000	-1,438	,150	2,628	3	,453	542,500	-3,343	**,001**
Q27	951,000	-1,158	,247	635,500	-1,289	,198	2,848	3	,416	577,500	-3,033	**,002**
Q28	889,500	-1,661	,097	470,500	-2,902	**,004**	10,317	3	**,016**	643,000	-2,521	**,012**
Q29	749,000	-2,729	**,006**	630,500	-1,334	,182	7,409	3	**,060**	483,500	-3,827	**,000**
Q30	967,500	-1,023	,307	593,500	-1,677	,094	4,109	3	,250	676,000	-2,190	**,029**
Q31	927,500	-1,346	,178	589,500	-1,733	,083	3,843	3	,279	488,000	-3,802	**,000**
Q32	800,000	-2,355	**,019**	565,000	-1,983	**,047**	9,629	3	**,022**	727,500	-1,789	**,074**

IV. DISCUSSION AND CONCLUSIONS

The most significant differences are related to the discrimination variable. This variable identifies those students who have suffered discrimination or another person in his/her context was discriminated against. The analysis shows that these previous experiences have a positive impact on the perception of the gender gap in computing. Nonetheless, it is important to highlight that the students who answer yes are not

only women. Specifically, there are 10 women, 15 men, 1 non-binary, and 2 preferred not to indicate.

The main differences are related to the social perception dimension (Fig. 1). People who suffer discrimination are more agree with items related to the gender gap as a problem of the technology sector and the society in general. In particular, they strongly agree that the gender gap is not a fad (Q29) and it is not a problem that only affects women (Q32). On the other hand, people who answer "No" to the discrimination questions are undecided about the need to increase the number of women in the technology sector (Q28) and mainstream gender in computer engineering studies (Q30). Moreover,

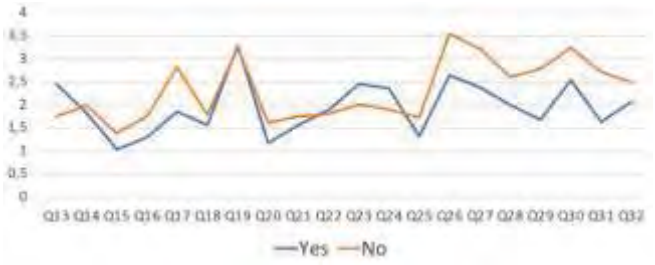

Fig. 1. Mean scores of the students per discrimination response in all the dimensions (Yes N=28, No N=67)

The data collected provides interesting results to go deeper in future studies. Despite the sample size, the case study provides useful information that complements other studies that analyze the factors that influence the gender gap, although caution must be applied, as the findings might not be transferable to all computer engineering students in Spain.

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