A preliminary study about gender gap perception in informatics studies in Spain

Alicia García-Holgado
Computer Science and Automation Department,, GRIAL Research Group, Universidad deSalamanca (https://ror.org/02f40zc51)
Salamanca, Spain
aliciagh@usal.es
0000-0001-9663-1103

Carina S. González-González
Computer Engineering Department, Instituto Universitario de Estudios de las Mujeres (IUEM), University of La Laguna
San Cristobal de La Laguna, Spain
cjgonza@ull.edu.es
0000-0001-5939-9544

Inmaculada García Fernández
Computer Architecture Department Universidad de Málaga
Málaga, Spain
igarciaf@uma.es
0000-0002-1138-2118

Lourdes Moreno López
Computer Science and Engineering Department Universidad Carlos III de Madrid
Madrid, Spain
lmoreno@inf.uc3m.es
0000-0002-9021-2546

Edurne Barrenechea
Departamento de Estadística, Informática y Matemáticas Universidad Pública de Navarra
Pamplona, Spain
edurne.barrenechea@unavarra.es
0000-0001-6657-948X

Silvia Rueda
Departament of Computer Science Universitat de València
Valencia, Spain
silvia.rueda@uv.es
0000-0002-1020-706X

Ángeles G. Navarro
Computer Architecture Department Universidad de Málaga
Málaga, Spain
angeles@ac.uma.es
0000-0002-4140-2589

Paloma Martínez
Computer Science and Engineering Department Universidad Carlos III de Madrid
Madrid, Spain
pmf@inf.uc3m.es
0000-0003-3013-3771

Belén Masiá
Computer Science Department Universidad de Zaragoza
Zaragoza, Spain
bmasia@unizar.es
0000-0003-0060-7278

Elena Navarro
Departament of Computing Systems Universidad de Castilla La Mancha
Albacete, Spain
Elena.Navarro@uclm.es
0000-0001-9496-6890

Alicia Fornés
Computer Vision Center Universitat Autónoma de Barcelona
Barcelona, Spain
afornes@cvc.uab.es
0000-0002-9692-5336

***Abstract*— The gender gap in STEM is an issue that affects regions and countries worldwide. Furthermore, the percentage of women in these areas depends on a range of different factors. In particular, the gender gap is critical in technology in general and, more specifically, in informatics. This problem affects not only the business sector but also society. Informatics is part of our lives; however, 50% of the world population is not represented in the teams that are developing solutions for solving society's problems. In Spain, the number of women with informatics degrees is around 15%. This work describes a case study developed by the committee of Women in Informatics at the Scientific Society of Spanish Informatics (SCIE) to analyse the perception of informatics scientists on the gender gap in informatics.**

Keywords*— *gender gap, informatics, Spain, women scientists, Computer Science.

I. Introduction

The low participation of women in higher education studies has been overcome in the last decades. According to the Global Gender Gap Report [1], 64 out 121 analysed countries have achieved gender parity in educational attainment (28 advanced economies and 36 emerging and developing economies from all regions).

However, gender parity is not achieved in tertiary education, although women actually exceed men in tertiary education attainment. In particular, STEM (Science, Technology, Engineering and Mathematics) areas are considered the most rigid for women to enter [2]. Moreover, the numbers differ between the specific STEM areas. The gender gap is more acute in engineering and technology [3]. According to the UNESCO report [4], around 30% of female students select STEM-related fields in higher education, and this number is reduced if we check female student's enrolment in Information and Communication Technologies (ICT) (3%) and engineering, manufacturing and construction (8%).

Women's representation among computer science degrees has fluctuated over the past decades. In the 1980s, numbers were around 40%, depending on the regions and the institution. However, the proportion of women declined in the 1990s, achieving critical numbers. In the United States of America, according to the National Center for Education Statistics [NCES] [5], women comprised only 18% of computer science graduates in 2014-2015, rising to 20.7% in 2018-2019.

Engaging more women in STEM is not only a problem that affects gender equality. According to the employment trends report prepared by Randstad Research, ICT sector employ 2.7% of the total number of workers in Spain, although it is one of the sectors that offers the best salary opportunities [6]. Having more women involved in technology development will help make the future tools more functional for all individuals [7]. Moreover, gender diversity is necessary to meet the demands of innovation and productivity in complex STEM environments [8-10]. Furthermore, including women in STEM processes guarantees improvement in the productivity and innovation of

STEM discoveries, technologies, and applications that will ultimately improve societies [11].

In Spain, according to the last gender gap index [1], the STEM index related to the percentage of male/female tertiary education graduates is 0.33 over 1. However, the gap is worst in ICT (0.12) and engineering, manufacturing and construction (0.29). In the 2021-2022 academic year, female students in ICT degrees represented only 15% of students enrolled [12]. The declining proportion of women in informatics degrees is also evident in the Spanish context. According to [13], in 1985-1986, female students in informatics was 30%, failing to 12% in 2016-2017.

In this context, the Spanish Scientific Society for Informatics (SCIE) has created a working group of "Women in Informatics" to reduce the work on the gender gap at the national level. The commission was created in June 2021 to analyse the current situation of women in computer engineering and the actions being developed by the different universities on their computer science schools and scientific societies to establish synergies and seek measures at national level to reduce the existing gap [14].

This paper describes the preliminary study conducted by the SCIE commission to find out the perception of the Spanish computer science research community regarding the gender gap in informatics. The study was conducted in September 2021 during the Spanish Computer Science Congress (CEDI 2021) in Málaga, Spain, using convenience sampling.

The work is organised into four sections. Section 2 presents the methodology. Section 3 describes the analysis and results collected. Finally, the last section summarises the main conclusions.

II. Methodology

A. Participants

The target population for the study was attendants of the sixth edition of the Spanish Computer Science Congress (CEDI 20/21) that the University of Málaga held in September 2021. The conference is a meeting place organised by SCIE for professionals dedicated to research, development, innovation and university teaching in the field of informatics engineering.

B. Instrument

We used an adaptation of the GENCE 2.0 (GENder perspective in Computer Engineering questionnaire) [15-17]. The questionnaire seeks to measure students' perception of gender differences in the computing section covering three dimensions through 20 five-level Likert items (Table I). The Likert scale expresses agreement (1=Strongly disagree, 2=disagree, 3=undecided, 4=agree, 5=strongly agree).

TABLE I. Likert items of GENCE 2.0 to measure the perception of the gender gap in computing

Academic perception (7 items)		Social perception (8 items)		Professional competence (5 items)	
Q013	Computer Engineering students are treated differently by their teachers according to their gender.	**Q015**	All people must have the same rights regardless of gender.	**Q018**	The women who make studies in Computer Engineering are not feminine enough.
Q014	People who enrol in Computer Engineering studies receive the same institutional support regardless of gender.	**Q016**	Gender equality is an important issue that must be addressed from all spheres (family, education, social, and work).	**Q020**	Women have more problems than men when programming.
Q017	Gender equality must be part of the University's curricula.	**Q019**	People who study Computer Engineering are considered "freaks" (rare).	**Q021**	Gender influences the fulfilment of Computer Engineering studies.
Q022	Men and women have the same opportunities to study engineering careers, such as Computer Engineering.	**Q028**	There is a need for more women to work in the technology sector.	**Q025**	Men are better prepared than women to work in the informatics sector.
Q023	People in Computer Engineering studies treat their peers of another gender in the same way.	**Q029**	The gender gap is a fad.	**Q026**	Nowadays, women have more problems than men in finding a job in the technology sector.
Q024	The professors in Computer Engineering studies treat all students equally regardless of gender.	**Q030**	The gender gap is not a problem that must be addressed as part of Computer Engineering studies.		
Q027	Nowadays, men and women receive the same remuneration for similar positions.	**Q031**	People working in the technology sector must help reduce the gender gap in their sector.		
		Q032	The gender gap is a problem that only affects women.		

The original version of the questionnaire also includes a set of questions related to the decisions made and the support received before enrolling in the computer studies (12 items) and 9 demographic items [16]. The version used in this study adapted these items to be used with researchers and academicians instead students. In particular, we removed demographic items about academic course and family, and we included two items to collect scientific society and university/institution. Regarding background, we removed items about family and experiences before starting their tertiary studies.

C. Data collection

We collected the data in September 2021 during the CEDI 20/21 Conference. We used a customised installation of LimeSurvey to digitalise the questionnaire. The conference chairs shared the link with all the attendants through email, both online and face-to-face. Attendants voluntarily participated and anonymity was guaranteed.

Regarding data analysis, we used SPSS Statistics 26 (License of the University of Salamanca). We pre-processed the items to have the same scale because some items are

formulated in negative. Furthermore, we measured the internal consistency for each dimension using Cronbach's alpha coefficient. We removed several items during this process to achieve alpha scores near the recommended value of 0.7. Table II shows the deleted items in each dimension.

TABLE II. INTERNAL CONSISTENCY.

	Cronbach's Alpha	Removed
Social perception	0.741	Q27
Professional competence	0.610	Q26
Academic perception	0.681	Q17, Q19

III. ANALYSIS AND RESULTS

A. Sample

The population was 500 attendants, and the sample size was 149 (95% confidence level and 7% precision). We collected answers from the ten scientific societies that compose SCIE[1] (Fig. 1). It should be notice that, although some researchers belong to more than one society, participants could only select one option.

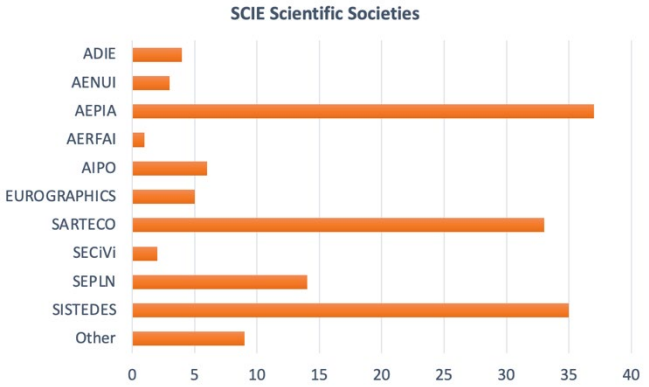

Fig. 1. Distribution of the sample by SCIE Scientific Society (n=149)

Regarding gender, 69 are men, 76 are women, 3 participants are non-binary and 1 participant preferred not to answer this question (Fig. 2). Concerning sexual orientation, 133 identify as heterosexual (89.29%), 8 as bisexual (5.37%), 2 as homosexual (1.34%), 5 prefer not to answer (3.36%) and 1 is not sure (0.67%).

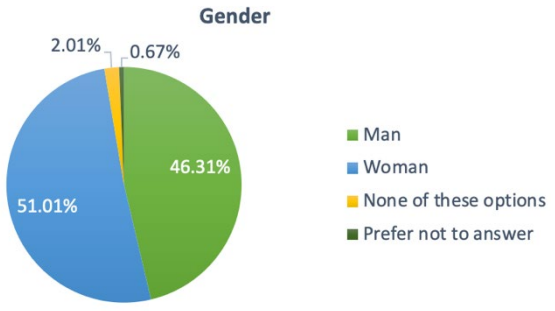

Fig. 2. Distribution of the sample by gender (n=149)

In terms of age, the question was posed with an age range of 5 years (Fig. 3). However, we have clustered them into three groups for further analysis: 50 participants are between 21 to 35 years (33.56%), 51 participants are between 36 to 50 years (34.23%), and 48 participants are between 51 and more than 60 (32.21%).

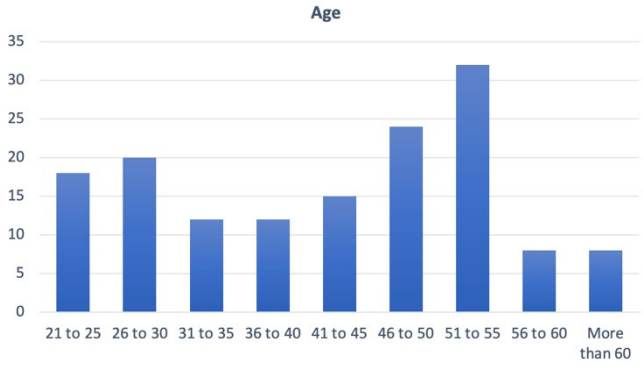

Fig. 3. Distribution of the sample by age range (n=149)

Finally, it is important to highlight the sample distribution regarding discrimination. We asked, "*Have you or anyone around you ever been discriminated against for belonging to a particular group (men, women, people of other sexual orientations, ethnicity, etc.)?*". 41.61% answer "*yes*", 54.36% answer "*no*", and 4.03% did not answer (n=149).

B. Descriptive analysis

The average of almost all items is near 4 (agree) or over 4 (Table III). Moreover, the mean score for each dimension is 3.96 for academic perception with a standard deviation (SD) of 0.795, 4.34 for social perception (SD=0.645), and 4.56 for professional competence (SD=0.634).

TABLE III. DESCRIPTIVE ANALYSIS

	N	Mean	SD	Min	Max
Q013R_ACA	149	4.03	1.130	1	5
Q014_ACA	148	4.19	1.225	1	5
Q022_ACA	149	4.00	1.310	1	5
Q023_ACA	149	3.66	1.206	1	5
Q024_ACA	149	3.93	1.157	1	5
Q015_SOCIAL	149	4.91	.464	1	5
Q016_SOCIAL	149	4.72	.754	1	5
Q028_SOCIAL	149	4.44	.961	1	5
Q029R_SOCIAL	149	4.29	1.029	1	5
Q030R_SOCIAL	149	3.59	1.390	1	5
Q031_SOCIAL	149	4.39	.998	1	5
Q032R_SOCIAL	149	4.04	1.320	1	5
Q018R_PRO	149	4.56	.925	1	5
Q020R_PRO	149	4.74	.817	1	5
Q021R_PRO	149	4.17	1.201	1	5
Q025R_PRO	149	4.76	.723	1	5

C. Analysis

The analysis is focused on answering the following research questions:

- **RQ1**. *What demographic characteristics such as gender or age influence the computer science researchers' perception of the gender gap in the area?*
- **RQ2**. *Does experiencing discrimination affect computer science researchers' perceptions of the gender gap in the area?*

The items do not follow a normal distribution for $p < 0.05$ in the Kolmogorov-Smirnov test, so non-parametric tests are used to perform hypothesis contrasts.

[1] https://www.scie.es/sociedades/

We performed hypothesis contrast to determine if the results depend on gender or age. The analysis does not consider sexual orientation due to the distribution of the sample is not homogeneous. First, we applied the Mann-Whitney U test for the hypothesis "Gender influences in the perception about the gender gap in informatics". We only considered women's and men's answers because the number of non-binary answers is not enough to compare. Table IV shows statistical differences in bold items for $p < 0.05$.

Regarding age, we applied the Kruskal Wallis test for the hypothesis "Age influences the perception about the gender gap in informatics". However, we reject the hypothesis because we only identified significant differences in item Q022_ACA "Men and women have the same opportunities to study engineering careers, such as Computer Engineering".

TABLE IV. MANN-WHITNEY U RESULTS FOR THE VARIABLE GENDER (N=149)

Items	U	Z	Sig
Q013R_ACA	2410,0	-,897	,370
Q014_ACA	2329,5	-1,154	.249
Q022_ACA	2360,0	-1,142	.253
Q023_ACA	2090,0	-2,184	**.029**
Q024_ACA	2177,0	-1,858	.063
Q015_SOCIAL	2500,5	-1,295	.195
Q016_SOCIAL	2140,0	-2,951	**.003**
Q028_SOCIAL	2334,0	-1,378	.168
Q029R_SOCIAL	2166,0	-2,021	**.043**
Q030R_SOCIAL	1926,0	-2,860	**.004**
Q031_SOCIAL	2345,0	-1,279	.201
Q032R_SOCIAL	2565,5	-,245	.807
Q018R_PRO	2622,0	,000	1,00
Q020R_PRO	2520,0	-,674	.500
Q021R_PRO	2013,0	-2,746	**.006**
Q025R_PRO	2583,5	-,254	.799

Fig. 4 shows the differences among mean scores clustered by gender. In this figure, we have included the non-binary answer to get the full picture, even if they could not be included in the statistical tests.

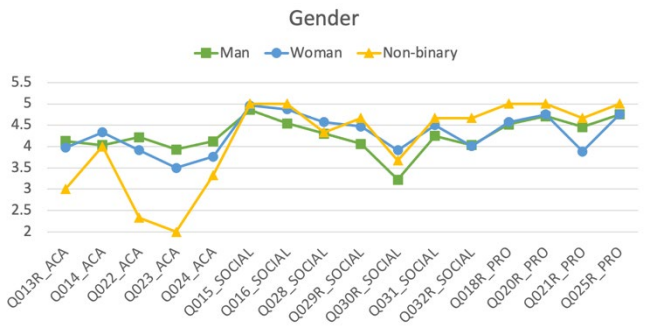

Fig. 4. Mean scores per gender (n=149)s

Concerning the second research question, the analysis was conducted for the hypothesis "Experiencing discrimination influences the perception about the gender gap in informatics". The results of the Mann-Whitney test show significant differences in most of the items, specifically those related to academic and social perception (Table V). The participants who did not answer this question were excluded from this test.

TABLE V. MANN-WHITNEY U RESULTS FOR THE VARIABLE DISCRIMINATION (N=143)

Items	U	Z	Sig
Q013R_ACA	1657.0	-3.701	**.000**
Q014_ACA	2216.5	-1.356	.175
Q022_ACA	1729.5	-3.470	**.001**
Q023_ACA	1690.5	-3.462	**.001**
Q024_ACA	1659.5	-3.656	**.000**
Q015_SOCIAL	2507.5	-.038	.970
Q016_SOCIAL	1974.5	-3.361	**.001**
Q028_SOCIAL	2118.0	-1.914	**.056**
Q029R_SOCIAL	1850.0	-3.007	**.003**
Q030R_SOCIAL	1723.0	-3.343	**.001**
Q031_SOCIAL	2070.5	-2.096	**.036**
Q032R_SOCIAL	2409.5	-.455	.649
Q018R_PRO	2325.0	-1.028	.304
Q020R_PRO	2477.5	-.232	.817
Q021R_PRO	2055.5	-2.136	**.033**
Q025R_PRO	2473.0	-.263	.793

Finally, Fig. 5 allows for discussing the significant differences related to discrimination.

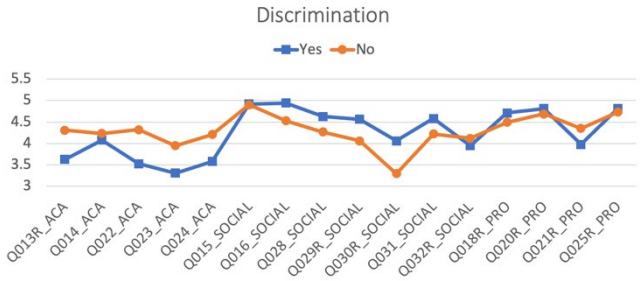

Fig. 5. Mean scores per discrimination variable (n=143)

IV. DISCUSSION AND CONCLUSIONS

Regarding the first research question, "*What demographic characteristics such as gender or age influence the computer science researchers' perception of the gender gap in the area?*", both hypotheses were rejected. Gender and age do not influence the perception of the gender gap in informatics. However, some items show significant differences. Highlight the results for Q030, where women and non-binary researchers tend to agree more than men that the gender gap is a problem that must be addressed as part of Computer Engineering studies (Fig. 4). On the other hand, men and non-binary researchers agree more than women that gender influences the fulfilment of Computer Engineering studies (Q021).

Concerning the second research question, "*Does experiencing discrimination affect computer science researchers' perceptions about the gender gap in the area?*", the hypothesis contrast confirms that experiencing discrimination, either in self or in someone close to you, has a positive impact on gender gap perception. According to the mean scores (Fig. 5), people who suffered discrimination identify more inequalities in the academic context of Computer Engineering studies. Moreover, they are more aware of the need to work on gender equality according to the mean scores of social perceptions. In addition, only 29% of men experimented discrimination, against 50% of women and 100% of non-binary researchers.

In previous studies, the discrimination variable also significantly impacts the gender gap perception of computer science students [16, 18, 19]. Another study conducted with

experts in engineering education [20] confirms that previous experiences also impact the perception of the gender gap in engineering.

These results provide an initial insight into how the computer science community perceives working on the gender gap in the field at the academic and scientific levels. Although the results are quite positive, there is still a need to raise awareness to create more inclusive and egalitarian spaces in computer science and for this to influence other aspects related to the gender gap in the field.

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