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Profiles of students in STEM across Latin America and Europe

Maria Giulia Ballatore*, Alicia García-Holgado**, Anita Tabacco^, Juanjo Mena***, Francisco José García-Peñalvo**, Lucía Amores**

Abstract

The gender gap in Science, Technology, Engineering and Mathematics is a problem that affects higher education institutions across the globe. Although some exceptions exist, such as Algeria, Benin, Oman or Myanmar (according to the Global Gender Gap Report 2022), women represent around 15% of STEM programs. The low number of women in these areas impacts the development of societies. STEM areas are crucial to solve society's problems and improving people's lives. However, half of the population (the females) is not represented in the teams that work to approach those problems. This work aims to analyse the profiles of current and past students from STEM programs in Latin American and European higher education institutions. We collected information about their motivations and concerns when they chose to enter university. We statistically analysed the differences finding that there are some significant ones. They mostly confirm the literature, showing that males and females have different views and approaches in the STEM field. Females look more for social aspects, while males tend to prioritise career perspectives. The findings suggest that there can be a mutual exchange of good practices between Latin American and European attraction campaigns thanks to the similarity found.

Keywords: gender gap, STEM, higher education institutions, undergraduate students, graduate students.

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1. Introduction

The gender perception of STEM (Science, Technology, Engineering and Mathematics) careers plays an essential role in the enrollment strategy in Higher Education (United Nations, 2019). Although more women than men are enrolled in tertiary education in most countries, the number of women choosing STEM careers is around 15% (UNESCO, 2017). Moreover, this percentage varies by region and STEM area. In Latin America and the Caribbean (LAC) context, women's academic engagement is oriented towards the care industry and disciplines related to the humanities (Bello, Estébanez, 2022). In LAC, women represent 70% of all students in the disciplines of education and health and welfare. In comparison, in areas such as mathematics and statistics, they represent only around 32% (except in Uruguay, where women are over-represented) (Red Indices, 2021; RICYT,2021).

In this context, the "Building the future of Latin America: engaging women into STEM" project (from now on, W-STEM project) aims to connect Europe (EU) with LAC to work on reducing the gender gap in STEM in the participant institutions introducing changes and new approaches in the mechanisms and strategies related to attraction, access and guidance of women students in STEM programs (Garcìa-Holgado, Garcìa-Peñalvo, 2022; Garcìa-Holgado *et al.*, 2020; Garcìa-Peñalvo *et al.*, 2019; Garcìa-Holgado *et al.*, 2019).

One of the aims of the EU-funded Capacity Building project, W-STEM, started in January 2019 and involved 15 Universities in 10 LAC (Universidad del Norte in Colombia, Tecnológico de Monterrey in Mexico, University of Guadalajara in Mexico, Federico Santa María Technical University in Chile, Pontifical Catholic University of Valparaíso in Chile, Technological University of Bolívar in Colombia, Costa Rica Institute of Technology in Costa Rica, University of Costa Rica in Costa Rica, Private Technical University of Loja in Ecuador, Technical University of the North in Ecuador) and European countries (University of Salamanca in Spain, Oulu University in Finland, Politecnico di Torino in Italy, Technological University Dublin in Ireland, Northern Regional College in United Kingdom), is to use this perception in order to create a more inclusive environment (W-STEM project, 2019). To achieve this goal, W-STEM considers some of the findings of the EU-funded Erasmus+ initiative project, Increasing Gender Diversity in STEM (INGDIVS). This latter project involved six EU universities (Karlsruhe Institute of Technology in Germany, KTH Royal Institute of Technology in Sweden, Politecnico di Torino in Italy, KU Leuven in Belgium, Trinity College Dublin in Ireland, and Técnico Lisboa in Portugal) and three high school partners (Vallauri in Italy, Our Lady's Schools in Ireland, and Heilig-Hartinstituut Heverlee in Belgium).

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The two projects have a common framework but slightly different goals. For INGDIVS, the main aim was to increase awareness of what it means to be an engineer and address some stereotypes associated with studying a technological field. For W-STEM, gender perception in technical fields is one of the elements that one should consider to define a recruitment strategy for Higher Education Institutions properly.

To achieve its objectives, INGDIVS has enabled a broad mass of young people to get a clearer picture of what an engineer does and address the youths' concerns and questions about engineering studies. This match was done by an interactive web-based tool called ANNA tool (Ballatore *et al.*, 2020), which allows students to identify themselves as an engineer in the future by searching for profiles similar to them in an anonymised database of profiles of current and past university students in engineering and technology. These profiles contained information about the motivations and concerns of current and past students when they chose to enter university – to provide some reassurance to future users of the tool that other people have shared similar concerns.

The gender perception task inside W-STEM starts by profiling present and past students to allow the matching between generations. This paper analyses the profiles the EU and LAC partners collected, looking for common patterns to support new policies.

The paper is organised into five sections. The second section will examine the current view of gender perception applied in a technical environment. In Section 3, the theoretical framework is presented. The fourth section is concerned with the methodology used for this study. The results are described in Section 5, followed by the discussion and conclusion.

2. Background

Gender equality is one of the focus areas of the UN Sustainable Development Goals. In particular, goal 5 states: "Gender bias is undermining our social fabric and devalues all of us. It is not just a human rights issue; it is a tremendous waste of the world's human potential. By denying women equal rights, we deny half the population a chance to live life at its fullest. Political, economic and social equality for women will benefit all the world's citizens. Together we can eradicate prejudice and work for equal rights and respect for all" (United Nations, 2019). A cultural shift is mandatory to ensure a sustainable world, particularly in the STEM sector. This change implies the involvement of the entire community (students, graduates, workers) and stakeholders. Nowadays, the "job of tomorrow" can become a good indicator of gender parity in the early future (World Economic Forum, 2021a). The

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analysis of the World Economic Forum shows significant challenges: only two of the eight emerging job clusters tracked are at gender parity, and three, the ones that require disruptive technical skills, show a severe under-representation of women. Precisely, Cloud Computing, where women share just 14% of the workforce; Engineering, with 20%; and Data and AI, with 32% (see Fig.1).

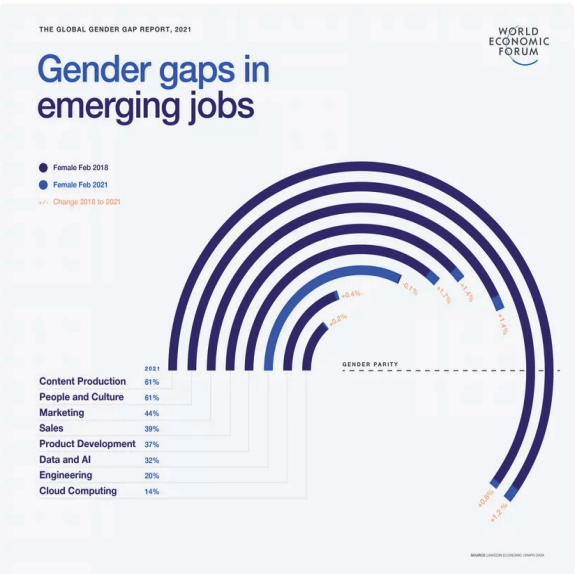


Fig. 1 - Gender gaps in emerging jobs (World Economic Forum, 2021b)

Advancing gender equality means making potential students feel that STEM education is something for them and creating education and future career open and inclusive for all people and scientific sectors. In 2015, with a focus on investigating the causes of this condition, UNESCO launched the STEM and Gender Advancement (SAGA) project. The study aimed to provide governments and politicians with indicators and tools to achieve a more sustainable world regarding gender equality (Polcuch *et al.*, 2018). In the meantime, a previous research project has shown that self-efficacy, that is, self-confidence and perception (of self in the role of engineer/technologist) are issues for high school girls (blind). Therefore, to work in Higher Education recruitment, one must be aware of the evidence-based strategies to put in place in favour of gender balance by paying attention to these critical points (students' self-confidence and perception). Self-efficacy beliefs can be mainly adopted in primary sources of information: mastery experience, vicarious experience, social persuasion, and physiological reaction (Rittmayer, Beier, 2009). The vicarious experience allows the creation of a network between future, current

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and past students introducing a "handly" role-model structure. It is well established that the positive influence of a good role model is not related to the gender itself but to how much it is perceived as similar to the observer (Cheryan *et al.*, 2011; Brury *et al.*, 2011). This strategy makes the stereotypes a marginal effect, so recruitment is found to be more efficacious (Hermann *et al.*, 2016).

On these beliefs, the Anna tool was created and allowed the collection and match of current and past students in EU countries. The researchers analysed the collected profiles to search for shared features of engineer/technologist self-efficacy (blind). This paper aims to deepen that analysis by comparing STEM perceptions based on different geographical locations (EU vs LAC countries).

3. Methodology

3.1. Instrument

We used the tool "Profiles of people in STEM careers", a survey based on the previous work developed by the INGDIVS project. This survey aims to gather data from current and past students to provide helpful information to potential STEM students and share similar concerns that others have had (W-STEM consortium, 2020).

The survey is divided into two sections, a general section to collect socio-demographic information and a section focused on creating a profile. Regarding the general items, there is a set of standard questions for active and graduate students (gender, birthyear, university, degree, pre-university education), and a set of questions only for graduate students (last academic degree obtained, graduate year, employment status, year of starting university).

On the other hand, the section to build the profile varies depending on whether the respondent is a graduate or an active student. The profiles will primarily help young people in secondary education to choose their future university career, increase their awareness of the importance of a STEM career and address some of the stereotypes associated with STEM-related university courses.

The items used for creating the profiles are described in Table 1. The questions are the same for active and graduate students, although some are adapted. The changes between questions for active or graduate are in blue. The profile created is also adapted. Specifically, the graduate student profile uses past tense verbs and includes information about the employment students (Fig. 2). The active student profile is in the present tense. It only includes information about current studies (Fig. 3).

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Table 1 - Items for defining the profiles

Question	ID	Answer options
Q1. My STEM degree allowed me to / I believe a degree in STEM will allow me to	Q1.1	meet a lot of really smart and interesting people
	Q1.2	work on some incredible projects with very experienced engineers
	Q1.3	work and travel around the world
	Q1.4	be making an impact on people's lives
Q2. My biggest concern before starting my STEM degree was / My biggest concern before starting my degree was	Q2.1	that the course would be too difficult for me
	Q2.2	that I wouldn't get enough experience working in teams or with other people
	Q2.3	that I might not fit in that well with the other students
	Q2.4	that I did not have enough hands on experience
Q3. The most surprising thing about it was / The most surprising thing about it is	Q3.1	that I was/am able to work on more projects that I initially thought
	Q3.2	how many options there were/are to choose from and how broad the course actually is
	Q3.3	the other students were/are a lot more like me than I thought they would be
Q4. The thing I like the most about studying at my university is / The thing I like the most about studying at my university is	Q4.1	the excellent international reputation the university has
	Q4.2	the facilities
	Q4.3	the location
	Q4.4	the interaction with the academic staff
	Q4.5	the other students I met from here

Source*: (W-STEM consortium, 2020)*

Hi my name is Shannon, I'm 28 years old and I graduated from University of Salamanca in 2008. A degree in STEM allowed me to work and travel around the world. Before I started university I had some fears that the course would be too difficult for me. The most surprising thing about it was that I was able to work on more team projects than I thought. I now work in the area of robotics engineering and I find that my STEM degree from University of Salamanca was invaluable to me getting here. The thing I liked most about studying at University of Salamanca was the interaction with the academic staff.

Fig. 2 - Example of profile for a graduate student. Source: W-STEM consortium (2020)

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Hi my name is Shannon, I'm 28 years old and I started studying at the University of Salamanca in 2018. I believe a degree in STEM will allow me to work and travel around the world. Before I started university I had some fears that the course would be too difficult for me. The most surprising thing about it is that I was able to work on more team projects than I thought. The thing I like the most about studying at the University of Salamanca is the interaction with the academic staff.

Fig. 3 - Example of profile for an active student. Source: W-STEM consortium (2020)

3.2. Population

The participants of this study are both active and graduate students in STEM fields, all of them belonging to universities in the different countries that are part of the W-STEM project (Fig. 4). It includes universities from EU and LAC countries: Spain, Ireland, Northern Ireland, Italy, Finland, Mexico, Chile, Ecuador, Colombia and Costa Rica.

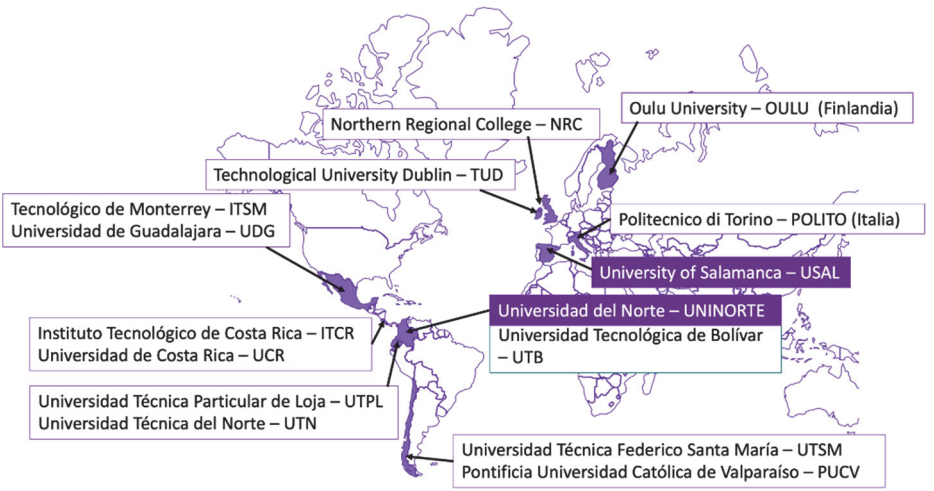


Fig. 4 - Distribution of the population involved in the study

3.3. Design and data collection

In this paper, we aim at:

1. Comparing gender career perceptions among male and female students enrolled in STEM degrees.
2. Describing the gender perceptions among female students belonging to EU or LAC universities.
3. Comparing if there are significant differences in gender perceptions in STEM degrees between graduate and undergraduate students.

The first step was to design the survey to collect the information. Two teams

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coordinated this step, one from blind and the other from blind, to ensure that the instrument was adapted to different cultural contexts. The process also involved other institutions in validating the instrument.

Regarding the survey application in each participant university, partners agreed to collect 100 profiles per institution (male, female, others) of university students and graduate students, trying to achieve 50% of university students and 50% of graduate students. The collection of profiles was carried out over a period of four months.

To collect the data, each partner sent emails to current and graduate students in their higher education institutions with a link to the survey in an online format. In particular, the survey was configured in a customised version of LimeSurvey hosted at the blind. Two versions of the survey were created, in English (http://profiles.wstemproject.eu) and Spanish (http://perfiles.wstemproject.eu), as it was aimed at students from different countries in LAC and EU. Participants were asked to answer anonymously.

3.4. Data analysis

The first type of analysis carried out is a descriptive statistical analysis, dedicated to organising, describing, visualising and summarising data generated from information collection. Such data can be summarised numerically – through frequencies and percentages – or graphically.

A second inferential analysis was used to look for differences in the perceptions of participants enrolled in STEM degrees according to their gender: female gender (group 1) and male gender (group 2). Subsequently, only female students were selected, and their perceptions were described according to the region they belong to, LAC (group 1) and EU (group 2). Finally, students' perceptions of their studies were compared to whether they graduated or not: graduated students (group 1) and active students (group 2).

In order to see the differences between the groups mentioned above, a Chi-square analysis was used. Then the effect size was calculated with Phi(φ) where n = number of cases observed, and a value of 0.1 is considered a small effect, a value of 0.3 a medium effect and a value of 0.5 a large effect. All these analyses were carried out using the SPSS v.26 statistical software.

4. Results

4.1. Sample

The total number of responses recorded was huge (n = 6538) and not well

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distributed across the different countries. Namely, the universities in Costa Rica collected 3363 answers, representing 51.44% of the total. Moreover, the LAC institutions collected more answers (5635, 88.63%) than the EU (723, 11.37%) due to the number of institutions in each region (10 LAC and 5 EU). While regarding the gender distribution: 54.01% were women, 45.33% were men, 0.31% were other, and 0.35% were non-answer (Fig. 5). Furthermore, according to their current situation, 32.57% were answered from active students, and 67.43% were graduate students.

Based on these statistics, the present study was conducted using a smaller sample size (n=1446). The parameters used to select the sample have focused on ensuring that it is statistically representative. It has been ensured that the representation of each region is equal and the gender distribution remains balanced in terms of men and women (as the answers collected under other options are not significant for statistical analysis).

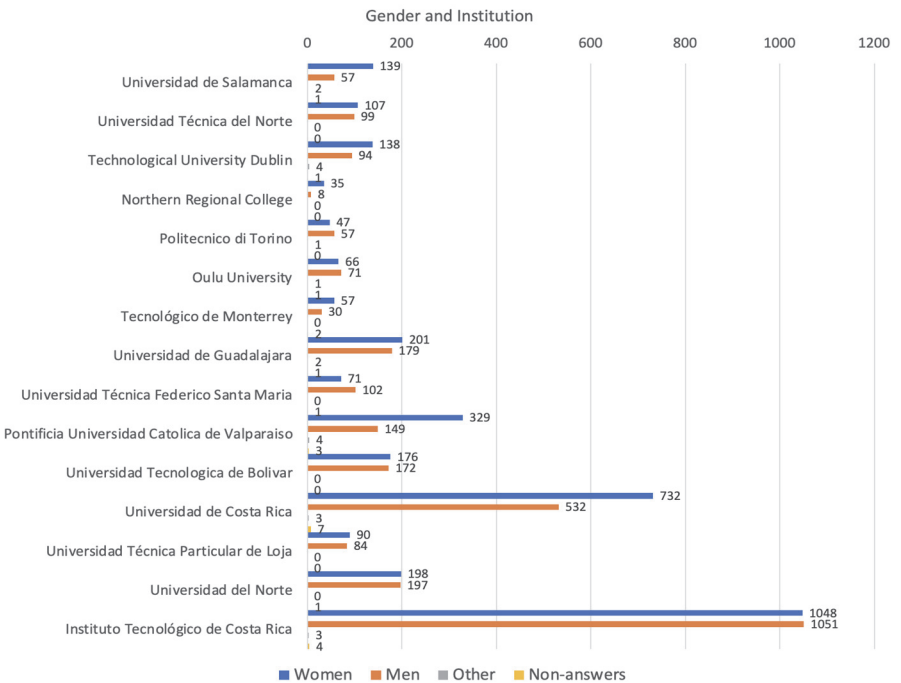


Fig. 5 - Distribution of the entire sample according to gender and institution

Regarding the region, all answers from the EU were included (723 answers), and the same number was selected for LAC. Moreover, in the EU, there is one institution per country, so we selected one for each LAC country (Table 2). The selection of the institution was randomised to avoid bias. There are some

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universities from which a higher number of responses were obtained than others, such as the Technological University Dublin (Ireland) with 16.4% or the University of Salamanca (Spain) with 13.8%. The lowest number of responses was recorded for Northern Regional College (Northern Ireland), with 3.0%, followed by Tecnológico de Monterrey (Mexico), with 6.2%.

Table 2 - Distribution of the selected sample per institution

Institution	Entire Sample	Entire Sample Percentage	Selected Sample	Selected Sample Percentage
Universidad de Salamanca (Spain)	199	3.13	199	13.8
Tecnológico de Monterrey (Mexico)	89	1.40	89	6.2
Universidad Técnica Federico S. María (Chile)	174	2.74	174	12.0
Universidad Técnica Particular de Loja (Ecuador)	174	2.74	174	12.0
Technological University Dublin (Ireland)	237	3.73	237	16.4
Northern Regional College (United Kingdom)	43	0.68	43	3.0
Politecnico di Torino (Italy)	105	1.65	105	7.3
Oulu University (Finland)	139	2.19	139	9.6
Universidad del Norte (Colombia)	396	6.23	143	9.9
Instituto Tecnológico de Costa Rica (Costa Rica)	2106	33.12	143	9.9
Total	**3662**	**57.6**	**1446**	**100,0**

In terms of gender, there is a better balance in the participation of both genders. However, the percentage of women (54.01%) is somewhat higher than that of men (45.1%). On the other hand, the percentage of active and graduate students remains similar to the entire sample, 68.7% are active students, and 31.3% are graduate students.

However, the percentage of responses from students from Latin America (50.2%) and Europe (49.8%) is almost equal, as we have tried to make the sample as balanced as possible in both regions.

On the other hand, they were asked about the STEM career they are studying or have studied. According to the answers obtained, the most frequent careers belong to the 'Engineering' category (62.1%). In second place is the 'Science' category (30.8%). The third place, with 4.9%, corresponds to 'Mathematics'. Finally, the least frequent studies are 'Technology' (1.8%).

4.2. Research questions

Gender perception in STEM degrees (n = 1446)

In this case, when comparing the students' perceptions according to gender,

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it can be seen that there are significant differences in only 7 of the variables (Table 3). In the remaining variables, approximately twice as many, there are no significant differences between male and female students, as the p-value is above 0.05.

The variables below 0.05 and, therefore, depend on the variable 'Gender' are Q1.2, Q1.4, Q3.1, Q3.2, Q4.1, Q4.5 and Q4.6. Of these, the most considerable percentage difference (7.3%) is in Q4.1 (What I liked/like most about my studies is the excellent reputation of the University), which is higher for males than for females. Closely following this is Q3.2 (The most surprising thing about the degree was/is that there are many options to choose from and that the discipline I chose has a wide field of action), with a difference of 7.2% in favour of the female gender.

As for the values of Phi (φ), it is observed that all of them are below 0.3, so the effect size measure is small for all variables.

Table 3 - Statistical report of gender perception in STEM degrees

Gender * Perceptions	Group 1 (females) (n=785)	Group 2 (males) (n=644)	Chi^2	p-value	φ
Q1.1	93 (11,8%)	68 (10,6%)	0.556	0.456	0.020
Q1.2	293 (37,3%)	277 (43,0%)	4.773	0.029*	0.058
Q1.3	160 (20,4%)	132 (20,5%)	0.003	0.957	0.001
Q1.4	194 (24,7%)	123 (19,1%)	6.459	0.011*	0.067
Q1.5	45 (5,7%)	44 (6,8%)	0.733	0.392	0.023
Q2.1	322 (41,0%)	247 (38,4%)	1.049	0.306	0.027
Q2.2	107 (13,6%)	96 (14,9%)	0.473	0.492	0.018
Q2.3	100 (12,7%)	79 (12,3%)	0.072	0.789	0.007
Q2.4	138 (17,6%)	129 (20,0%)	1.399	0.237	0.031
Q2.5	118 (15,0%)	93 (14,4%)	0.098	0.754	0.008
Q3.1	148 (18,9%)	164 (25,5%)	9.063	0.003*	0.080
Q3.2	488 (62,2%)	354 (55,0%)	7.736	0.005*	0.074
Q3.3	100 (12,7%)	84 (13,0%)	0.029	0.864	0.005
Q3.4	49 (6,2%)	42 (6,5%)	0.046	0.829	0.006
Q4.1	166 (21,1%)	183 (28,4%)	10.129	0.001*	0.084
Q4.2	100 (12,7%)	79 (12,3%)	0.072	0.789	0.007
Q4.3	70 (8,9%)	64 (9,9%)	0.434	0.510	0.017
Q4.4	106 (13,5%)	85 (13,2%)	0.028	0.866	0.004
Q4.5	265 (33,8%)	188 (29,2%)	3.406	0.065	0.049
Q4.6	78 (9,9%)	44 (6,8%)	4.365	0.037*	0.055

Note: * = $p < 0.05$

Women's perception in STEM degrees in LAC and EU (n = 785)

As can be seen in Table 4, in most of the variables, there are significant differences in the perceptions of female students between the LAC and EU regions. The only variables with no such difference are Q1.3, Q1.5, and Q4.6,

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where the percentage of response between students from one region and the other is equal. Therefore, it can be said that these three variables are independent of the variable 'Region in which the university is located'.

As for the rest of the variables, the greatest discrepancy in percentages can be seen in Q4.1 (What I most liked/like about my studies is the excellent reputation of the university), with a difference of 27.5% in favour of LAC students. Another variable with a big difference between the percentages is Q4.5 (What I most liked/like about my studies is the other students I have met), with a 17.9% gap, in this case in favour of European women.

On the other hand, if we look at the values of φ, we see that the effect size measure is small in all the variables, as its value is below 0.3. The only exception is the variable Q4.1, where φ has a value above 0.3; therefore, the effect size measure is medium.

Table 4 - Statistical report of women's perception in STEM degrees in LAC and EU

Region * Perceptions of women	Group 1 (women in LAC) (n = 370)	Group 2 (women in EU) (n = 415)	Chi^2	p-value	φ
Q1.1	31 (8,4%)	62 (14,9%)	8.063	0.005*	0.101
Q1.2	168 (45,4%)	125 (30,1%)	19.535	0.000*	0.158
Q1.3	78 (21,1%)	82 (19,8%)	0.211	0.646	0.016
Q1.4	74 (20,0%)	120 (28,9%)	8.357	0.004*	0.103
Q1.5	19 (5,1%)	26 (6,3%)	0.462	0.497	0.024
Q2.1	138 (37,3%)	184 (44,3%)	4.007	0.045*	0.071
Q2.2	71 (19,2%)	36 (8,7%)	18.369	0.000*	0.153
Q2.3	35 (9,5%)	65 (15,7%)	6.771	0.009*	0.093
Q2.4	80 (21,6%)	58 (14,0%)	7.892	0.005*	0.100
Q2.5	46 (12,4%)	72 (17,3%)	3.703	0.054	0.069
Q3.1	84 (22,7%)	64 (15,4%)	6.778	0.009*	0.093
Q3.2	249 (67,5%)	239 (57,6%)	8.129	0.004*	0.102
Q3.3	21 (5,7%)	79 (19,0%)	31.410	0.000*	0.200
Q3.4	16 (4,3%)	33 (8,0%)	4.398	0.036*	0.075
Q4.1	132 (35,7%)	34 (8,2%)	88.603	0.000*	0.336
Q4.2	70 (18,9%)	30 (7,2%)	24.047	0.000*	0.175
Q4.3	15 (4,1%)	55 (13,3%)	20.379	0.000*	0.161
Q4.4	24 (6,5%)	82 (19,8%)	29.502	0.000*	0.194
Q4.5	90 (24,3%)	175 (42,2%)	27.853	0.000*	0.188
Q4.6	39 (10,5%)	39 (9,4%)	0.286	0.593	0.019

Note: * = $p < 0.05$

Gender perception in STEM degrees in graduate and undergraduate students (n = 1446)

As can be seen in the Table 5, comparing the perceptions between graduate and undergraduate students, significant differences are found in 12 of the variables: Q1.1, Q1.2, Q1.4, Q1.5, Q2.1, Q2.3, Q2.5, Q3.1, Q3.2, Q3.4, Q4.3, and Q4.6. The rest of the variables do not show significant differences between

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both groups of students, i.e. they do not depend on whether they have already graduated.

The highest difference is in variable Q1.1 (e.g. My university degree has allowed/will allow me to meet a lot of interesting people). The percentage of graduate students who gave this answer (23.6%) is much higher than that of undergraduates (5.6%). Another quite significant difference is in the variable Q2.5 (e.g. My main concern before starting my studies was...other), where 11% more graduates than non-graduates ticked this response. Very close to this is also the variable Q1.4 (e.g. My university degree has allowed/will allow me to make an impact on people's lives), in which there is a difference of 10.7%, but this time in favour of non-graduates.

On the other hand, looking at the values of φ, we can say that the effect size measure is small for all variables, as they are below 0.3.

Table 5 - Statistical report of gender perception in STEM degrees in graduate and undergraduate students

Graduates / Active students * Perceptions	Group 1 (graduates) (n = 450)	Group 2 (active students) (n = 996)	Chi^2	p-value	φ
Q1.1	106 (23,6%)	56 (5,6%)	99.890	0.000*	0.263
Q1.2	148 (32,9%)	426 (42,8%)	12.645	0.000*	0.094
Q1.3	82 (18,2%)	215 (21,6%)	2.149	0.143	0.039
Q1.4	67 (14,9%)	255 (25,6%)	20.553	0.000*	0.119
Q1.5	47 (10,4%)	44 (4,4%)	19.091	0.000*	0.115
Q2.1	152 (33,8%)	423 (42,5%)	9.777	0.002*	0.082
Q2.2	61 (13,6%)	144 (14,5%)	0.207	0.649	0.012
Q2.3	41 (9,1%)	141 (14,2%)	7.172	0.007*	0.070
Q2.4	95 (21,1%)	174 (17,5%)	2.714	0.099	0.043
Q2.5	101 (22,4%)	114 (11,4%)	29.623	0.000*	0.143
Q3.1	121 (26,9%)	193 (19,4%)	10.287	0.001*	0.084
Q3.2	239 (53,1%)	612 (61,5%)	9.024	0.003*	0.079
Q3.3	47 (10,4%)	140 (14,1%)	3.591	0.058	0.050
Q3.4	43 (9,6%)	51 (5,1%)	10.031	0.002*	0.083
Q4.1	104 (23,1%)	247 (24,8%)	0.481	0.488	0.018
Q4.2	48 (10,7%)	135 (13,6%)	2.338	0.126	0.040
Q4.3	28 (6,2%)	109 (10,9%)	8.057	0.005*	0.075
Q4.4	69 (15,3%)	123 (12,3%)	2.397	0.122	0.041
Q4.5	148 (32,9%)	308 (30,9%)	0.554	0.457	0.020
Q4.6	53 (11,8%)	73 (7,3%)	7.711	0.005*	0.073

Note: * = $p < 0.05$

5. Discussion and conclusions

Considering the first question, the most selected answer is Q1.2 (see Fig. 6). The answer refers to the possibility of entering challenging projects thanks to a

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STEM degree. This answer presents a significant difference in favour of males who have yet to graduate. If one considers only women, the LAC area has a statistically more significant weight than European women. Regarding the cluster graduates/active students, the difference may be due to the work experience itself. Although respondents are asked to answer by putting themselves in their shoes when choosing a university, there is no doubt that work experience can influence self-perception before starting studies.

The second most frequent response is Q1.4 which presents a significant slight difference in favour of women still in progress and, among these, a European majority. Men seem more linked to their career and working ambition, while women prioritise social and family aspects. Choice Q1.3 (work and travel around the world) presents no significant differences between the categories studied. Instead, answer Q1.1 (meet a lot of really smart and interesting people) presents significant differences in favour of European graduate students.

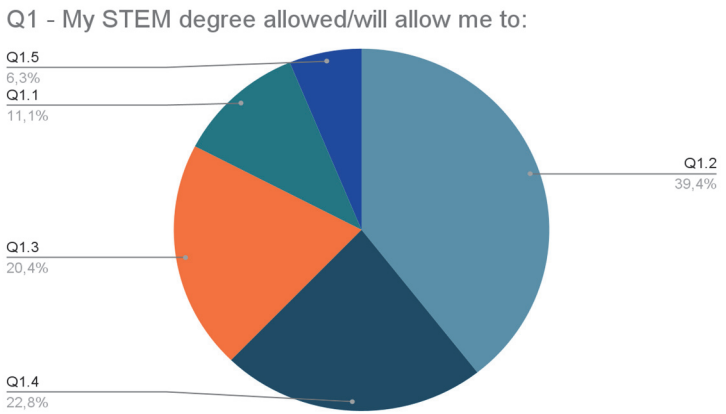


Fig. 6 - Distribution of answers in Q1

The second statement, "My biggest concern before starting my STEM degree was", does not present significant gender differences, which are, however, present among women if one considers the region to which they belong (Fig. 7). Europeans tend to be more concerned with the level of difficulty (Q2.1) and social interaction (Q2.3), while LAC puts practical (Q2.4) and group (Q2.2) experiences at the fore. Regarding the graduate and student categories, only the statements related to the difficulty level (Q2.1) and social condition (Q2.3) present significant differences, both in favour of the students.

Almost 15% of the population chose the item "other", which was codified. The main concern is employment and professional growth. Other relevant items

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concern choosing the right career or the career one "likes", financial matters, or not being sufficiently prepared.

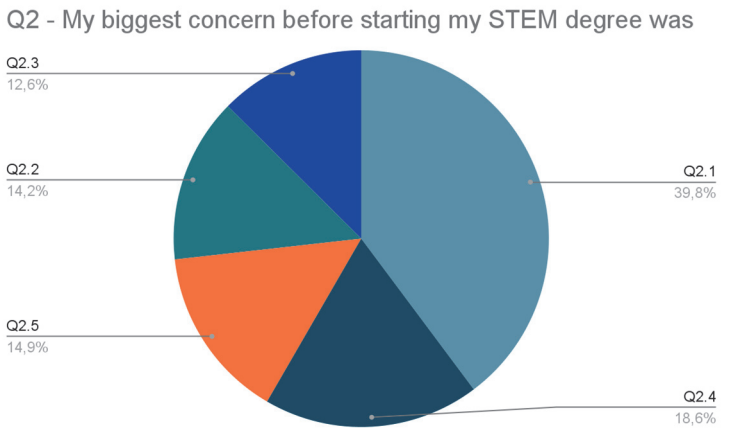


Fig. 7 - Distribution of answers in Q2

The statement concerning the vastness of the selected sector (Q3.2) is the most representative of the sample analysed (Fig. 8). This answer presents a significant difference in favour of men and university graduates. If only women are considered, there is a preference for LAC. The statement regarding the possibility of working on many projects (Q3.1) was also chosen by many people with a significant difference in favour of women and students. This evidence allows us to understand how the aspects related to group experiences are perceived as having little characterisation in STEM by the girls, who then find themselves positively surprised. LAC women again tend to identify more with this response. Answer Q3.3 and the answer “Other” show a significant difference in favour of European women and, in the case of Q3.4, students. Also, from the distribution of the answers, it seems evident that the majority favours the strictly working component compared to more relational and empathetic aspects without any gender imbalance.

As shown in Fig. 9, the majority (36%) state that the thing they like the most about studying at their university is the students they have met (Q4.5). This answer presents a significant difference only among women, favouring European ones. The second most chosen option is the international reputation (Q4.1), which receives a 23% preference. This international aspect seems to be more in favour of males. Although, when considering females only, there is a significant difference in favour of LAC. Regarding the female population again, the other four answers (Q4.4, Q4.2, Q4.3, Q4.6) always present a significant

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difference in favour of the EU. Analysing the free text inside the answer Q4.6, it seems clear that most students appreciate the quality of education, that is, the type of preparation during the university career and the first jobs. That includes, for example, laboratory experience and hands-on aspects. Other common patterns can be summarised with the words “topic”, meaning that they liked the content and the path chosen and “opportunities”, referring to the possibilities they had thanks to their study. The answer Q4.6 has a significant difference in favour of graduate students, probably due to the personal reflections on their education path once they entered the labour market.

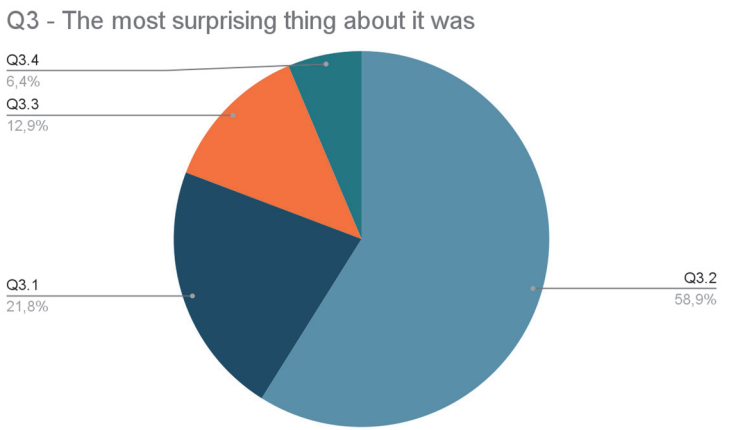


Fig. 8 - Distribution of answers in Q3

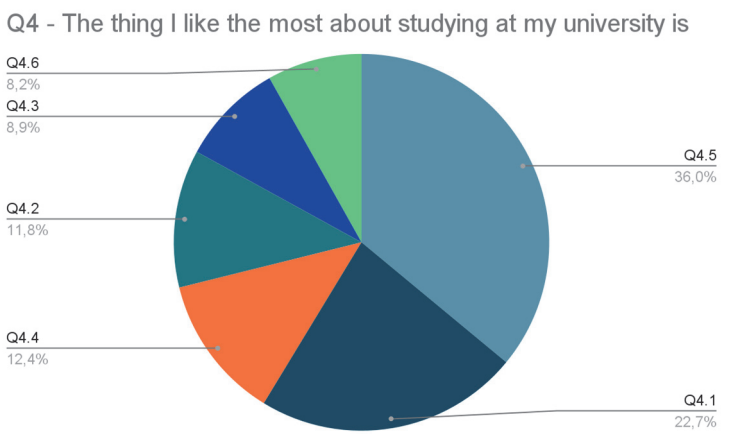


Fig. 9 - Distribution of answers in Q4

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In general, this study presents some limitations. The data collection was done at the beginning of the COVID-19 pandemic. Health restrictions afflicted the data collection. Therefore, some countries collected more data compared to others. Then, there is not an equal representation of the different countries. Although the answers refer to the University's experience pre-pandemic situation.

In the end, one can see that the study findings are similar to those obtained in the INGDIVS project (blind). This result means that the feeling at the beginning of University are similar between EU and LAC, although some small significant differences can be found inside the female only. In general, this study confirms with field evidence the literature showing that females tend to link the STEM choice to social and family perception while males to career and working ambitions. One can find these patterns in all four questions. However, it is important to remark that all the significant differences found had a small φ meaning that the effects were small. Considering the attraction campaign run by the university, all data confirm that there can be a mutual exchange between EU and LAC experiences.

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Declaration of conflicting interests

The Authors declare that there is no conflict of interest.

Author Statement

All authors jointly designed the contribution. In the writing and revision stage, Sections 1 and 3 were developed by all authors; Ballatore and Tabacco developed sections 2 and 5; Amores, Mena, García-Holgado, and García-Peñalvo designed section 4.

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Data Availability Statements:

The dataset generated by the survey research during the current study is available at https://docs.google.com/spreadsheets/d/1wWR9H2zyk-Y05IpLaCfU38yFYDeJKbN13kyJNLq6ZsI/edit?usp=sharing

Compliance with Ethical Standards:

The authors report no conflict of interest.

The project protocol was approved by the Ethics Committee of the University of Salamanca (Spain) to collect the data anonymously. Reference number 557. The informed consents were collected through the online form.

References

Ballatore M.G., De Borger J., Misiewicz J., Tabacco A. (2020). ANNA Tool: a way to connect future and past students in STEM. *IEEE Revista Iberoamericana de Tecnologías del Aprendizaje, 15*(4): 344-351.

Bello A., Estébanez M.E. (2022). An unbalanced equation: Increasing participation of women in STEM in LAC (MTD/SC/2022/PI/01).

Cheryan S., Siy J.O., Vichayapai M., Drury B. J., Kim S. (2011). Do female and male role models who embody STEM stereotypes hinder women's anticipated success in STEM?. *Social psychological and personality science, 2*(6): 656-664.

Drury B. J., Siy J.O., Cherya, S. (2011). When do female role models benefit women? The importance of differentiating recruitment from retention in STEM. *Psychological Inquiry, 22*(4): 265-269.

García-Holgado A., Camacho Díaz A., García-Peñalvo F.J. (2019). Engaging women into STEM in Latin America: W-STEM project. In: Conde-González M.Á., Rodríguez Sedano F.J., Fernández Llamas C., García-Peñalvo F.J. (Eds.). *Proceedings of the 7th International Conference on Technological Ecosystems for Enhancing Multiculturality* (TEEM 2019) (León, Spain, October 16-18, 2019) (pp. 232-239). ACM. Doi: 10.1145/3362789.3362902.

García-Holgado A., García-Peñalvo F.J. (2022). A Model for Bridging the Gender Gap in STEM in Higher Education Institutions. In: García-Peñalvo F.J., García-Holgado A., Dominguez A., Pascual J. (Eds.). *Women in STEM in Higher Education: Good Practices of Attraction, Access and Retainment in Higher Education* (pp. 1-19). Springer. Doi: 10.1007/978-981-19-1552-9_1.

García-Holgado A., Mena J., García-Peñalvo F.J., Pascual J., Heikkinen M., Harmoinen S., García-Ramos L., Peñabaena-Niebles R., Amores L. (2020). Gender equality in STEM programs: a proposal to analyse the situation of a university about the gender gap. In: 2020 IEEE Global Engineering Education Conference

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(EDUCON), (27-30 April 2020, Porto, Portugal) (pp. 1824-1830). IEEE. Doi: 10.1109/EDUCON45650.2020.9125326.

García-Peñalvo F.J., Bello A., Domínguez A., Romero Chacón R.M. (2019). Gender Balance Actions, Policies and Strategies for STEM: Results from a World Café Conversation. *Education in the Knowledge Society, 20*(15). Doi: 10.14201/eks2019_20_a31.

Herrmann S.D., Adelman R.M., Bodford J.E., Graudejus O., Okun M.A., Kwan V.S. (2016). The effects of a female role model on academic performance and persistence of women in STEM courses. *Basic and Applied Social Psychology, 38*(5): 258-268.

Polcuch E.F. Brooks L.A., Bello A. (2018). Telling SAGA: Improving measurement and policies for gender equality in science, technology and innovation. SAGA Work. Paper 5, Paris France.

Red Indices. (2021). Red Iberoamericana de Indicadores de Educación Superior -Red IndicES-. Testo disponibile alla pagina: http://www.redindices.org/.

RICYT. (2021). Red de Indicadores de Ciencia y Tecnología-Iberoamericana e Interamericana- (RICYT). Available: http://www.ricyt.org/.

Rintala U. *et al.* (2012). Knowing our students-different approaches to student retention experiences of the ATTRACT project. Proc. 40th SEFI Annu. Conf., Thessaloniki, Greece, 2012.

Rittmayer M.A., Beier M.E. (2009). Self-Efficacy in STEM. In B. Bogue & E. Cady (Eds.). Applying Research to Practice (ARP) Resources. Available: http://www.engr.psu.edu/AWE/ARPresources.aspx.

UNESCO. Director-General 2009-2017 (2017). Cracking the code: girls' and women's education in science, technology, engineering and mathematics (STEM). UNESCO. Available: http://bit.ly/2k8nhns.

United Nations. Goal 5: Achieve Gender Equality and Empower All Women and Girls. Accessed: Sep. 2019. Testo disponibile alla pagina: https://www.un.org/sustainabledevelopment/gender-equality/.

World Economic Forum, Global Gender Gap Report 2021. Available: https://www.weforum.org/reports/global-gender-gap-report-2021#report-nav.

World Economic Forum, Global Gender Gap Report 2021 – infographics. Available: https://www.weforum.org/reports/global-gender-gap-report-2021/infographics-ad8db6203f.

W-STEM Consortium, "Profiles of people in STEM careers," W-STEM D2.3.1 – Version 1.1. Available from: https://zenodo.org/record/6815875. doi: 10.5281/zenodo.6815875.

W-STEM Project. ENGAGING WOMEN INTO STEM: Building the Future of Latin America. Accessed: 2019. [Online]. Available: https://wstemproject.eu/.

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