ARE OUTREACH ACTIONS EFFECTIVE IN INCREASING THE REPRESENTATION OF WOMEN IN STEM FIELDS?

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Abstract

The gender gap is a well-documented phenomenon in STEM (Science, Technology, Engineering, Mathematics) fields globally. Spanish universities, including the Superior School of Technology and Experimental Sciences (ESTCE) at Universitat Jaume I (UJI), exhibit a significant underrepresentation of women in most STEM degree programs. This disparity can be attributed to underlying psychological and sociocultural factors, emphasizing the urgent need for proactive dissemination policies that enhance the visibility of women scientists, mathematicians, engineers, and architects, and foster STEM aspirations among young women.

This study aims to analyze the prevailing gender gap within STEM disciplines at ESTCE-UJI and examine its evolution in recent years, taking into account the dissemination initiatives implemented by UJI to promote women's participation in these fields. By correlating the gender gap trends with the university's outreach efforts, valuable insights can be gained to inform and improve future policies aimed at bridging the gender divide in STEM.

Keywords: Dissemination actions, STEM degrees, Women.

1 INTRODUCTION

STEM (Science, Technology, Engineering, Mathematics) is the acronym introduced by the U.S. National Science Foundation (NSF) to refer to the field and curriculum focused on the education of science, technology, engineering, and mathematics disciplines. Originally coined as SMET, the acronym was reorganized in 2001 by American biologist Judith Ramaley, who was then the Deputy Director of Education and Human Resources at the NSF [1].

The inclusion of women in the workforce began in the 20th century in the most advanced societies, with varying levels of activity depending on the fields [2]. Although nowadays there is no question about women's capacity to engage in science, the data seems to indicate otherwise. Since 1903, when Marie Curie received the Nobel Prize, only 23 women, compared to 595 men, have been awarded a Nobel Prize in the fields of science (physics, chemistry, or physiology/medicine) [3].

The gender gap is an evident fact within STEM studies. In Spain, there is a clear male dominance in the enrollment of STEM degrees, a circumstance that is aggravated by the fact that women, mainly, represent a higher proportion of those who pursue higher education, accounting for 54.1% according to data from the INE in 2020 [4]. Although these studies are increasingly in demand in the job market, with growing future prospects [5], women's perception of the utility of STEM careers contradicts the projections regarding labor market demand. Women often consider degree programs in the social sciences and humanities to offer more professional opportunities [6,7]. However, even within STEM fields, there is an uneven distribution of women, with a much more pronounced gender gap observed in engineering in Informatics, Telecommunications, Electrical and Electronics (ITEE), where a distinct profile of female students has been identified compared to other STEM fields [8].

As a result of the increasing demand for professionals in the field of STEM, initiatives in Spain have been on the rise in recent years with two objectives, both from public and private entities as well as non-profit scientific associations: promoting studies encompassed in STEM areas and eliminating the existing gender gap. These initiatives are primarily targeted towards primary and secondary school students, with much fewer resources dedicated to professional women [7]. In fact, secondary education is considered a critical stage where girls begin to distance themselves from science and mathematics. Although it has been observed that there is almost no gender gap in terms of performance in science, there is a significant gender gap in STEM career expectations [9].

But why do women prefer careers in the healthcare, social sciences, or legal fields over STEM careers? It seems that the reasons are diverse: cultural factors, pre-established stereotypes, family environment, lack of female role models, low visibility and recognition of women in science, discrimination, and difficulties in

work-life balance in the industrial setting, among others [10]. In addition to these psychological or sociocultural causes [11,12], there is an irrational belief that suggests the existence of a biological explanation, evidenced by the fact that certain biological traits influence behavior, enabling women to be more interested in people-oriented occupations, while men prefer activities oriented towards things [13]. It is therefore essential to promote actions that increase the visibility of women scientists, mathematicians, engineers, and architects, and thus foster STEM vocations among young women.

In addition to the need for educational actions starting from the early stages of education, it is essential to focus on families since it is within the family unit where a second-year high school student makes the decision regarding which degree to pursue. The figure of the mother or female guardian has the greatest influence on the choice of a STEM degree [14].

Only 28.8% of scientific positions worldwide are held by women, a figure that decreases to 26% in the technology sector. In Spain, these numbers are even worse, with only 16% of women in STEM professions [15]. This gender gap is also evident in the enrolment of women in STEM university programs, which stands at 30%. Furthermore, the expectations of women to continue their studies are even more significant, especially in engineering or computer science fields, where less than 5% of women in OECD countries express a desire to pursue advanced studies. This hostile environment, as evidenced by the graduation data of female students, is also reflected in the academic representation within faculties, which in turn negatively impacts the graduation rate of female STEM students [16,17].

Therefore, the role of universities in reducing this gender gap is crucial, and it should be a priority objective in teaching and learning processes. Increased support for STEM students throughout their academic journey is essential [17,18].

This article focuses on analysing the gender gap within STEM careers at the School of Technology and Experimental Sciences (ESTCE) of the Universitat Jaume I (UJI), as well as studying the relationship between this gender gap and the outreach actions organized by UJI to promote women's presence in these fields.

2 METHODOLOGY

This study has examined the evolution of women's presence in STEM degrees at Universitat Jaume I (UJI) from 2013 to 2021, focusing exclusively on those offered by the Superior School of Technology and Experimental Sciences (ESTCE, as known by its initials in Spanish).

In the same period, the dissemination initiatives organized by the university to promote the presence of women in these fields have been analysed. These initiatives include a wide range of activities such as conferences, programs, lectures, exhibitions, workshops, etc., primarily aimed at the general public or secondary school students.

The 13 degrees offered by ESTCE have been grouped into the four STEM categories as follows: *Science* ('Biochemistry and Molecular Biology' and 'Chemistry'), *Technology* ('Computer Engineering', 'Robotic Intelligence' and 'Video Game Design and Development'), *Engineering* ('Agrifood and Rural Engineering', 'Chemical Engineering', 'Electrical Engineering', 'Industrial Design and Product Development Engineering', 'Industrial Technology Engineering', 'Mechanical Engineering' and 'Technical Architecture') and *Mathematics* ('Computational Mathematics').

The study has encompassed the evolution of both the student body (new admissions -IS and graduates -GS) and the faculty teaching staff (TS), as well as the teaching load that this faculty has in the various degrees – credits (C).

3 RESULTS AND DISCUSSION

In Fig. 1, the evolution of female STEM professors and students is analysed. It can be observed that, in the case of the faculty across all four study groups, the values are significantly far from 50% (which would indicate gender parity). However, a slight upward trend can be noticed (except for group T), with values ranging from 20-30% in 2013 to approximately 30-40% in 2021.

If we analyse the teaching workload of these female professors, a separation between the S-E and T-M groups becomes evident. While the former experience an increase in teaching load during the analysed period, the latter show no variation. Again, all of them remain well below the 50% mark.

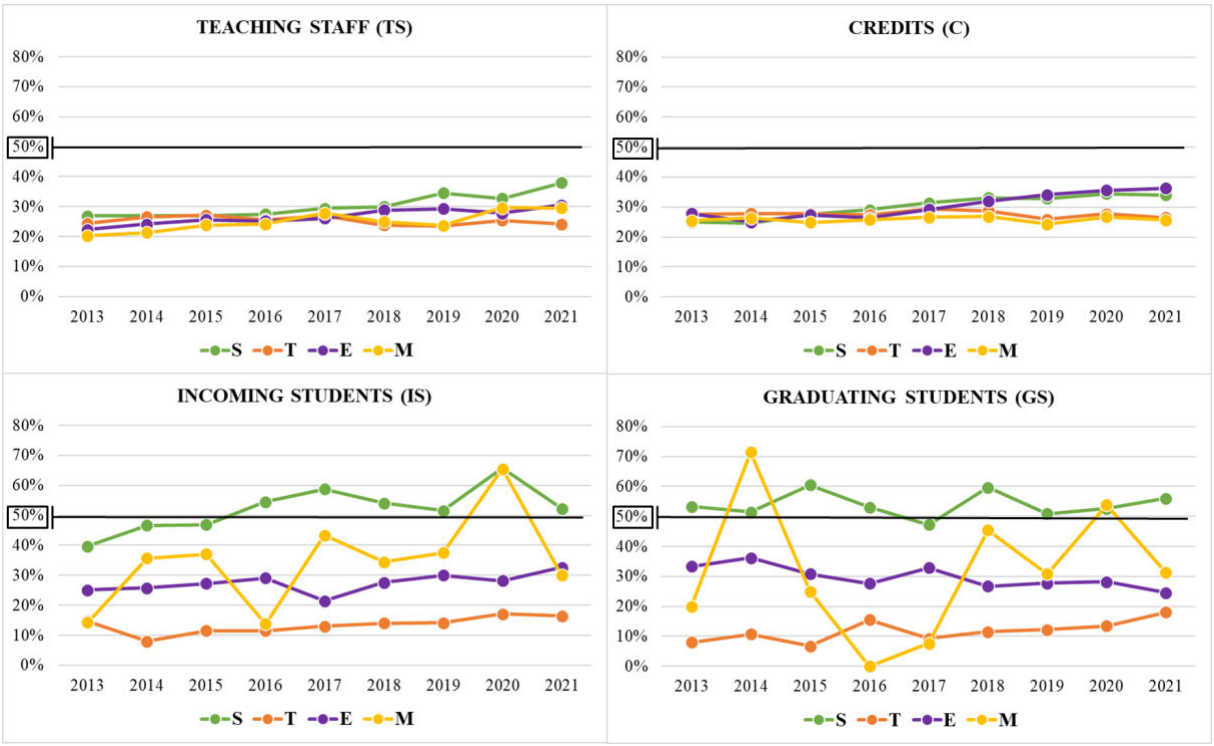


Figure 1. Evolution of women's presence in STEM degrees at UJI: faculty - teaching staff (TS), teaching workload of the faculty – credits (C), incoming students (IS), and graduating students (GS).

The evolution of the student body differs significantly from that of the faculty. In this case, the trend shows no significant growth, except for the incoming female students in the S group, where a slight increase from 40% to 50% is observed. Currently, this group has achieved similar values to those of male students. However, the incoming female students in the E and T groups remain well below parity values, with a presence of 30% in E degrees and 20% in T degrees.

When analysing the graduating female students, the same pattern repeats, with parity values observed only in the S degrees. The E degrees show values ranging from 30% to 25%, while the T degrees exhibit values of 10% to 20%. Once again, the Technology (T) group has the lowest representation of women.

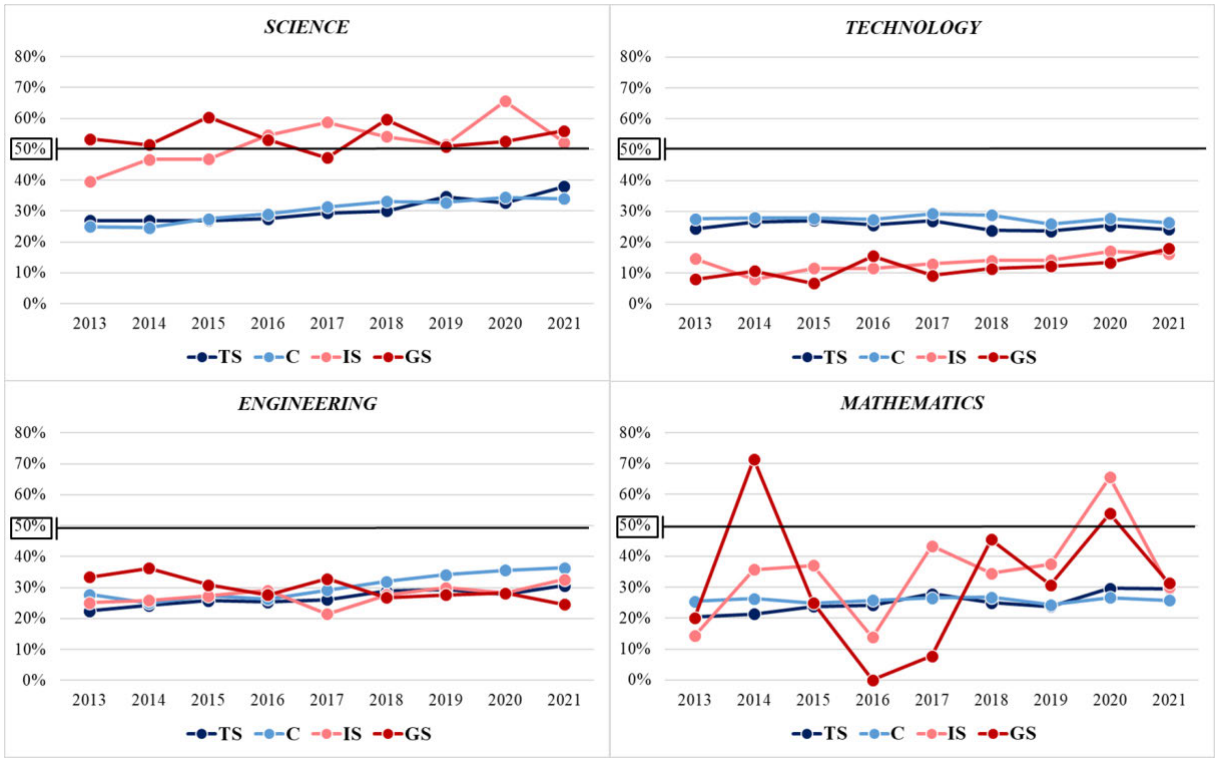
The dispersion of the values for M in the student body is quite significant, generally falling below 50%. However, there are some peaks where this value is exceeded. This data dispersion can be attributed to the fact that this group consists of a single degree program, 'Computational Mathematics', which has a small intake group of 30 students and an emphasis on computer science in its curriculum. This typically attracts more males than females, with variations occurring randomly from year to year.

Fig. 2 displays the evolution of female faculty - teaching staff (TS) and their teaching workload – credits (C), as well as the incoming (IS) and graduating (GS) female students in the four STEM groups. It reveals a distinct pattern for each of these categories.

In the *Science* (S) group, the presence of women among the student body is significantly higher than that among the faculty. The percentage of female students surpasses 50%, while the percentage of female faculty hovers around 30-40% (with a slight upward trend).

In the *Technology* (T) group, the trend is reversed, with a higher presence of women among the faculty compared to the student body, although both groups still fall short of achieving gender parity. However, there is a noticeable growth from 10% to 20% in the presence of female students during the study period.

In the *Engineering* (E) group, the presence of women in both the faculty and student body is similar, but remains well below 50%, and there is no clear increasing trend. In this group, it can be observed that the teaching workload of female faculty is higher than the percentage of total faculty, indicating that female professors may hold lower professional positions and/or have had a shorter research trajectory, which is associated with a heavier teaching load. This same trend is also observed, though to a lesser extent, in the case of faculty in the *Technology* (T) group, while no such trend is evident in the *Science* (S) or *Mathematics* (M) groups.



E

Figure 2. Evolution of female faculty-teaching staff (TS) and their teaching workload – credits (C), as well as the incoming (IS) and graduating (GS) female students in STEM degrees at UJI: S (Science), T (Technology), E (Engineering), and M (Mathematics).

In *Mathematics* (M), making comparisons between groups is challenging due to the significant data dispersion concerning female students. However, it is evident that the percentage of female faculty is notably distant from the 50% mark. On the other hand, the student body (both incoming and graduating) shows a trend towards achieving gender parity.

In conclusion, there is a very low percentage of women who choose to pursue STEM careers (except for Science). This low representation persists among graduating individuals. On a professional level, women in Technology (T) who pursue careers in university teaching improve the percentage compared to graduating women in this field. However, they still fall far from achieving gender parity. The situation is even more concerning for women in Science (S), as despite an equal number of male and female graduates in this field at UJI, the percentage of female faculty remains as low as in other STEM fields. In the case of Engineering (E), the percentage of female graduates and faculty generally align, but both figures are far from parity. Overall, it is necessary to continue taking action at all levels to reverse the underrepresentation of women in STEM fields, including educational, occupational, and societal initiatives.

Regarding the actions implemented by the university to reduce the gender gap in the STEM field, it can be observed that the enrolment of women in STEM programs slightly increases with the number of actions, particularly in the case of *Science* (S) (Fig. 3). However, there is no clear effect (with some cases even showing negative slopes) on the percentage of female graduates or faculty members.

It appears, therefore, that the policies implemented to date have only achieved relative success in increasing STEM vocations among young pre-university women. It is necessary to expand both the number of actions taken and the target groups they are directed towards. This should include specific initiatives for female university students and professional graduates, with the aim of combating attrition not only during their degree programs but also throughout their entire professional careers.

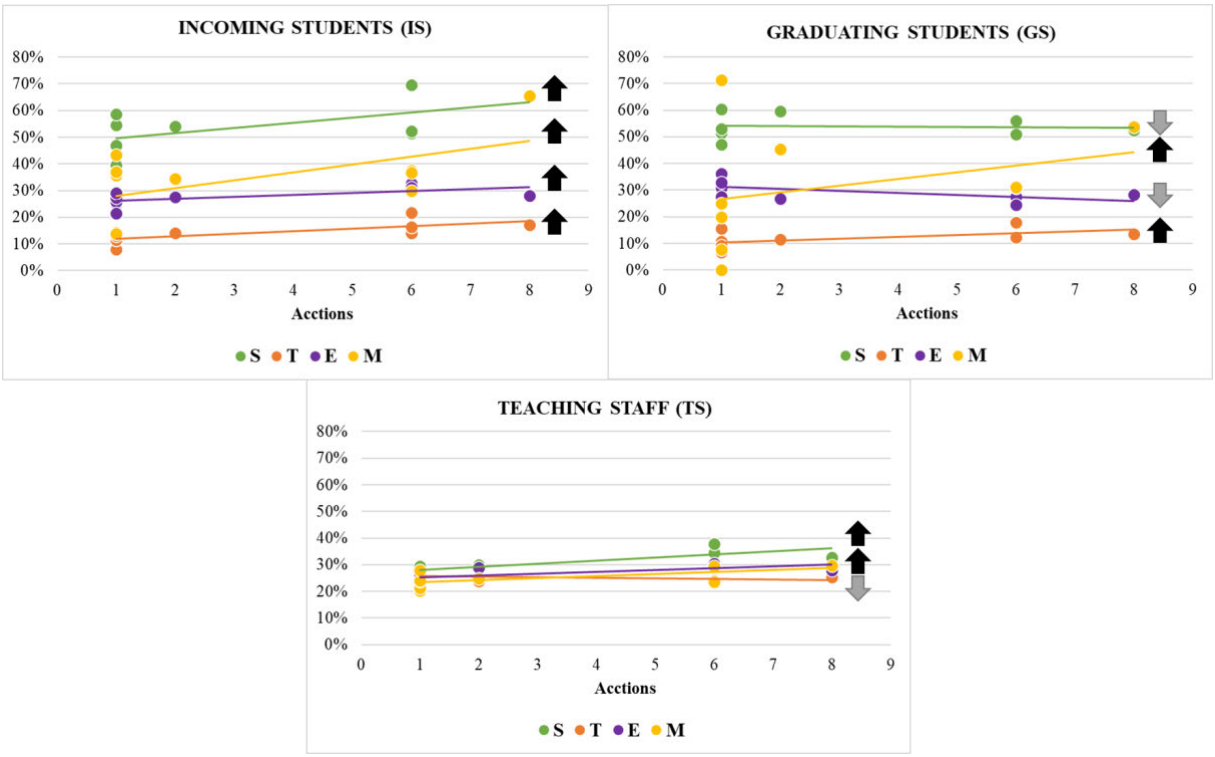


Figure 3. Relationship between the percentage of incoming (IS) and graduating (GS) female students and female faculty-teaching staff (TS) in STEM degrees at ESTCE and the number of actions implemented at UJI during the period 2013-2021.

4 CONCLUSIONS

The Superior School of Technology and Experimental Sciences (ESTCE) at Universitat Jaume I (UJI) is not an exception within the Spanish university system, and similar to the global trend, a significant (yet non-uniform) gender gap is evident in the enrolment of STEM degrees, with Technology exhibiting a particularly pronounced gap. The heterogeneity observed in enrolment among different STEM groups diminishes among graduating students and faculty members, slightly reducing the existing gender gap at the expense of the Science group. Science, which initially achieves enrolment parity, experiences substantial masculinization upon completion of undergraduate studies and in professional development.

The outreach initiatives organized by the university to promote female presence in these fields have had limited impact on STEM degree enrolment and virtually no effect on the number of female graduates and faculty members. This underscores the need not only to increase efforts in such policies but also to expand and strengthen the target groups, with particular emphasis on the university and academic spheres. This is essential to improve the success rates of graduation and professional careers.

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