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Science and gender

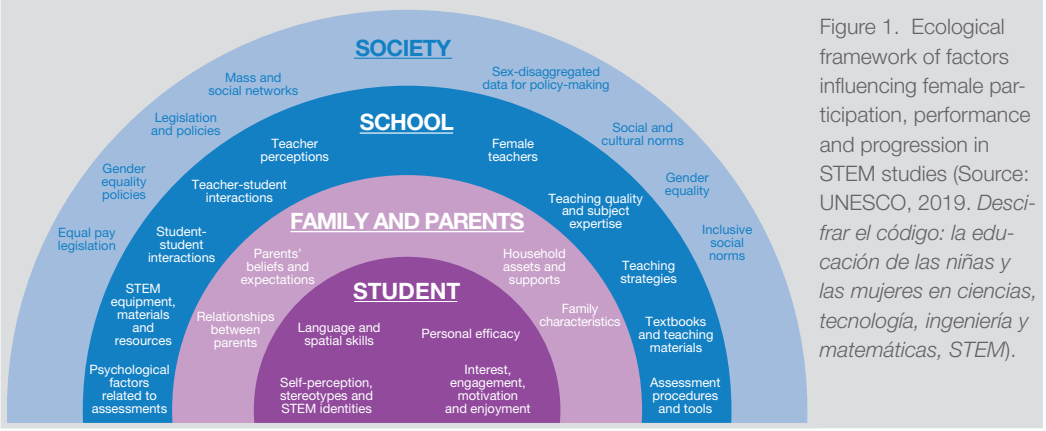

Figure 1. Ecological framework of factors influencing female participation, performance and progression in STEM studies (Source: UNESCO, 2019. *Descifrar el código: la educación de las niñas y las mujeres en ciencias, tecnología, ingeniería y matemáticas, STEM*).

1. The need for scientific and technological vocations

There is a broad consensus on the importance of scientific and technological professions, as well as on the relevant role of scientific and technical education for young people.

Based on the STEM concept (Science, Technology, Engineering and Mathematics), we distinguish between non-technological STEM subjects, related to the bio-health field (medicine, pharmacy or veterinary medicine) or the more experimental field (chemistry or physics), and technological STEM subjects (engineering, architecture and other technological fields). It is in this last group where we find a clear gap in relation to the presence of women.

And this gap is not irrelevant. STEM-related careers will be essential for the global economy, as these areas are where most employment will be generated. The demand for STEM profiles is growing in the Spanish labour market, according to the Spanish Association for Digitalisation (DigitalES), which points out that in 2018 there were at least 10,000 job vacancies in the technology sector, and estimates that between 2017 and 2022, 1,250,000 jobs will be created as a result of digitalisation.

This situation is all the more worrying given the unforeseen acceleration of the digitalisation process that the COVID-19 crisis has brought about. In this context, the creation of STEM jobs, the presence of ICT and big data experts, and the scientific and technical literacy of society will become increasingly urgent, given the vulnerability of society in a post-expert digital world.

2. The need for female vocations in scientific and technical careers

In most European countries, women represent less than 45% of the scientific and technological community.[1] Looking at both STEM fields separately, the gender bias is accentuated, especially in technological STEM. The picture is even more critical in university degrees, as only 35% of students enrolled in STEM degrees are women.

Given that we cannot do without 50% of the population in the labour market and that there is a clear future opportunity for youth, female vocations in STEM must be promoted to enable:

– The fulfilment of Goal 5 of the SDG 2030: gender equality and women's empowerment.

– A greater enrichment of our vision of the world and of economic activity (inclusive and diverse vision in the design and production of goods and services).

– Facing market demand since by 2020, as expected, 50% of the most demanded profiles are related or linked to engineering and technology, with an increase of 14% per year.

– Align with the 2030 Agenda for sustainable development, the basis of which is the STEM disciplines as providers of the knowledge and attitudes needed to create inclusive and sustainable societies.

3. Causes and influencing factors for female vocations in STEM careers

The importance of family, social and educational environments

According to different experts, the first gender stereotypes emerge in childhood and are rein-

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forced in adolescence by the presence of male teachers, especially in STEM subjects.[2] In fact, between the ages of twelve and sixteen, girls' interest in science decreases compared to their peers. Considering that interest in science emerges in primary education, it would not make sense to focus all efforts on improving performance only in secondary education, as many students will be demotivated earlier.[3]

The reasons for these differences are therefore to be found in social, family or educational factors (see Figure 1), among which psychological factors also play a prominent role.

UNESCO considers that the factors that play a determining role in the interest of girls and women in STEM disciplines are the immediate family environment, the social environment and the education systems and schools.

Some studies show that girls are more influenced by the school and family environment than boys. For this reason, if we seek to understand the under-representation of girls in STEM careers, we need to look at interests, as the choice between STEM (technological and non-technological) and non-STEM careers reflects clear "individual interest patterns", which have different weights for boys and girls.

The role of parents and teachers is crucial. Buschor *et al*.[4] analysed female secondary school students and their inclination towards STEM careers over two years. The qualitative analysis revealed that learning experiences, parental support and role models were decisive in the students' career choices.

In addition to the above-mentioned factors, there are other personal factors. Shelley Correll,[5] of Stanford University, believes that boys do not choose mathematics disciplines to a greater extent than girls becaused they are better at them. They do so, at least partially, because they believe they are better.

UNESCO highlights in particular this self-selection bias, which would be the main reason why girls fail to choose STEM education and a future career in the same line, influenced mainly by their environment, to which must be added the conviction that STEM disciplines are fundamentally male-dominated.

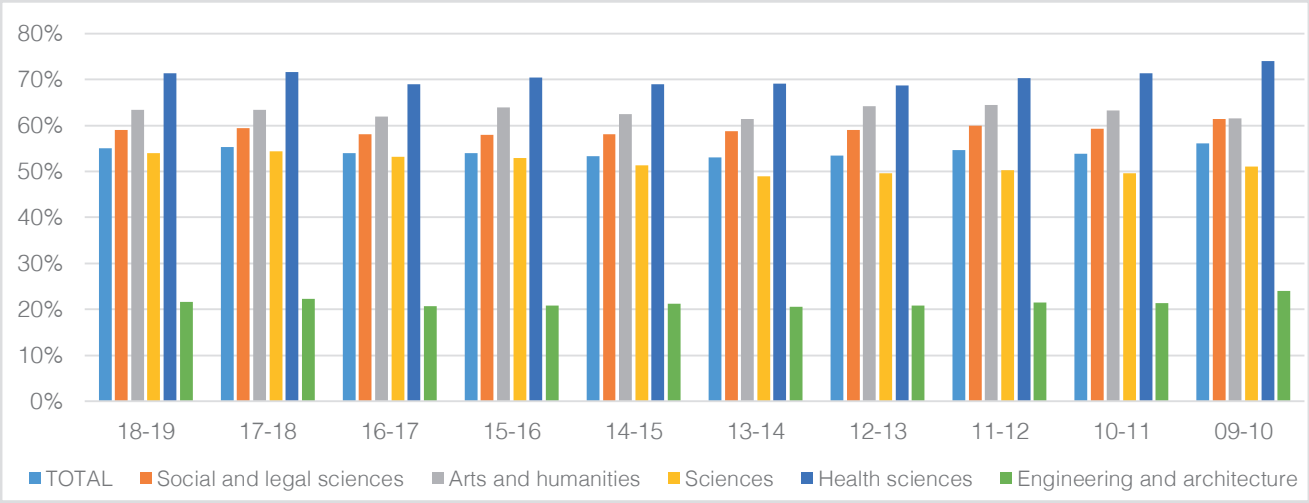
Media, television series and social networks

In the world of communication, the influence of certain series on university vocations is striking, something that has become clear with what has been called the "CSI effect", a series that increased forensic vocations. Something similar happened in the case of female vocations in science thanks to the "Scully effect", originated by this female character in the *X-Files* series. A study on this effect[6] found that 63% of female scientists who were twelve years old when the series premiered would probably not be where they are now if it had not been for this character.

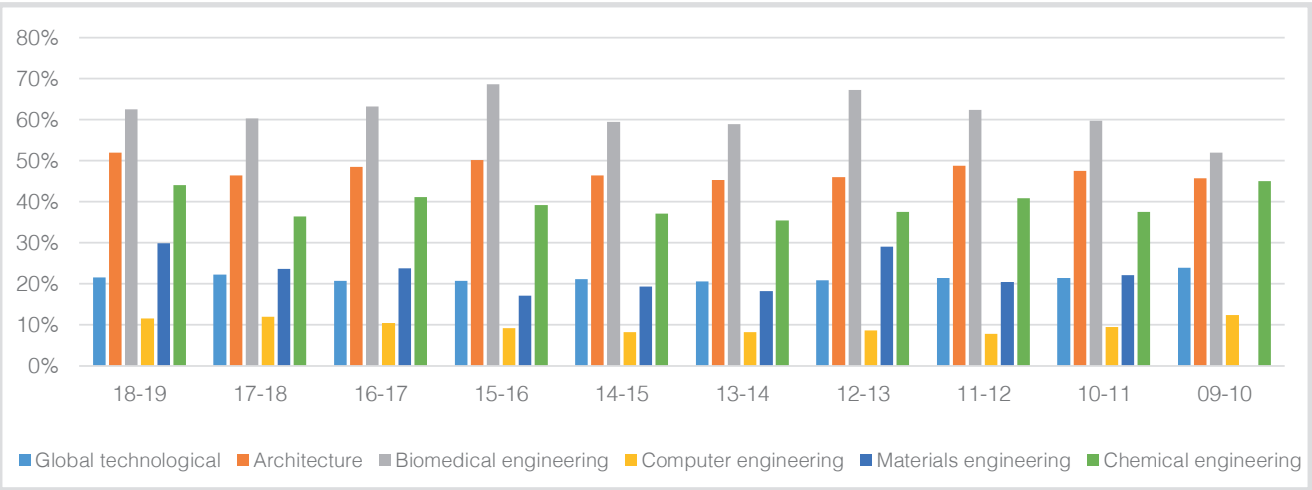
In fact, according to research conducted by the Lyda Hill Foundation and the Geena Davis Institute, a better portrayal of women scientists in the media would encourage more women to take an interest in these fields. This study[7] shows that 62.9% of STEM characters are played by men, a figure that has not changed in the last ten years. These entertainment media reinforce stereotypes about which STEM fields are more appropriate for women: there are fewer women than men as physics scientists (6.4% compared to 11.8%) or in computer science jobs (8.6% compared to 11.5%), but certainly the worst gender-biased figure is for female engineers (2.4% compared to 13.7% of boys).

Motivations: interest in social good, health and interpersonal relationships

Lightbody *et al* [8] noted a "female preference for occupations" that are people-oriented or related with these occupations. This desire to be of service or in relation to society through professional work should not be underestimated in the approach to studies or in the naming of STEM careers.



Graphic 1. Percentage of new female students by field (Source: own elaboration based on data from Uneix, Secretaria d'Universitats i Recerca -SUR-, Generalitat de Catalunya).



Graphic 2. Percentage of newly admitted students in some technological degrees (Source: own elaboration based on data from Uneix, SUR, Generalitat de Catalunya).

Su and Rounds state that men prefer things-oriented careers (*things-orientation*), while women prefer people-oriented professions (*people-orientation*). For this reason, different studies indicate that girls tend to be more interested in health, the human body and medical studies within scientific careers.

In this sense, the "academic stereotypes" of certain careers act as "gatekeepers" that keep women away from certain fields. For example, computer science and engineering are perceived as "masculine" careers in which women perceive social isolation and a machine-oriented approach.

4. The situation in Catalonia

The situation in Catalonia confirms this reality. In order to determine the situation of women's scientific careers in the Catalan university system, the data of all the official degrees taught in the last ten academic years were analysed.[9] The data analysed were "newly admitted students"[10] and "graduate students". They were obtained separated by sex and by branch of knowledge.

Graph 1 shows that the overall percentage of women newly admitted to the university system of Catalonia (SUC) over the last ten academic years is around 55%.

However, a significant difference can be observed between the different fields, with the health sciences field standing out at the top, where women account for 70%, and engineering and architecture at the bottom, where, over the same period, women account for around 20%.

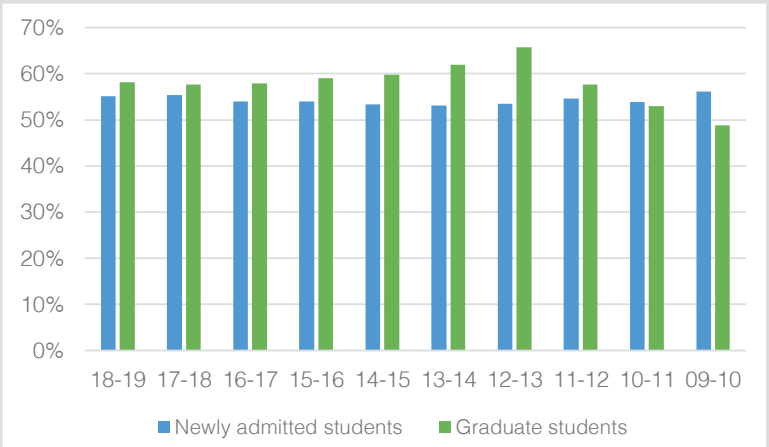
A discrete analysis of the behaviour of some engineering and architecture degrees shows that women's interest in non-technological STEM is markedly higher than in materials engineering or computer science (Figure 2). However, despite being an engineering field, biomedical engineering has a slightly lower percentage of women new entrants (around 60%) than health sciences as a whole. Architecture also stands out as a STEM of female interest.

Apart from the analysis in terms of the presence of women in certain disciplines, it can be observed that, from a qualitative point of view, women perform better than men.

The data contained in the information system do not make it possible to distinguish between men and women in the drop-out rate, but it can be observed that the percentage of women new entrants is lower than the percentage of women among graduate students. This fact leads to the intuition that the drop-out rate of men is higher than that of women (graph 3).

For a more detailed analysis, linear regressions have been performed with the Stata 16 platform on the variables yield rate,[11] efficiency rate[12] by degree and average grade point average. The regressions incorporate additional information: university, branch, sub-branch and academic year, and assign weights according to the number of enrolments or graduates according to the variable of interest.

The overall results show that the three variables present a statistically significant difference, with women performing better than men. Specifically, women, in relation to men, show higher values in performance (3.46%), efficiency (0.95%) and grades (7.81%).



Graphic 3. Percentage of women in the Catalan university system (Source: own elaboration based on data from Uneix, SUR, Generalitat de Catalunya).

Analysing engineering and architecture degrees separately, the results show that women outperform men by a statistically significant 2.8% in the achievement rate.

Therefore, although the percentage of women entering technological STEM careers is low, they show very positive data in performance and continuity. The data seem to confirm that the female self-limiting factor keeps women away from these careers. It also confirms that women are interested in what we could call *Humanistic Engineering* and that the gap has a socio-educational character.

5. Recommendations for structural change

In the family environment

– A real education in equality and active listening by parents to their children, discovering their true life project.

– The work of making women's roles in STEM careers more visible involves normalising these professions in the family environment.

– Collaborating with schools and continuing social learning processes at home.

In the social environment

– Promote greater visibility of women in STEM fields in the media.

– Promote series, films and other audiovisual content in which women play leading roles in the STEM field.

– Use the communication channels preferred by young people and which have Instagram and YouTube influencers as references. It would be very interesting to involve these influencers, even if they are not from the scientific field, in a campaign to promote female STEM vocations.

In the educational environment

– Work on the motivation of girls from a positive self-concept: all careers are for everyone. There are no careers for boys or for girls.

– Highlight the social utility behind all careers, including STEM careers.

– Recognise the work of teachers in the vocational process. Focus on primary education as the first moment of interest in science. Encourage more women teachers in this field as scientific role models.

– Promote teaching strategies that integrate STEM into educational projects and consider the diversity of students.

– Take care of the environment and equipment in which STEM takes place, and avoid social isolation and a focus on machines.

– Develop language, spatial and numeracy skills in childhood. These skills are highly predictive of future performance in STEM.

– Promote parental engagement in this line of work, with particular emphasis on families with fewer resources.

– Create a sense of belonging in relation to STEM studies and careers by increasing girls' exposure to STEM experiences.

– Develop skills such as self-confidence and personal self-efficacy.

– Promote more socially oriented engineering curricula that bring meaning to ***Humanistic Engineering***.

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9. Data extracted from the university information system Uneix of the Secretariat for Universities and Research (data from 7 June 2020).
10. Students accessing the degree for the first time and who do not have more than 30 recognised ECTS credits.
11. Percentage of ordinary credits passed with respect to the ordinary credits enrolled in an academic year.
12. Percentage, for graduates in a given academic year, between the number of theoretical credits required to obtain a degree and the number of credits that a student must enrol to obtain a degree.

PARLAMENT DE CATALUNYA

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