The gender gap in Secondary and High School Students in STEM fields

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***Abstract*— The gender gap in STEM vocations among high school students still remains a troubling reality. Several studies indicate that students in general have less interest in science and technology subjects, and this disparity is even more distinguishable among female students. In fact, the aforementioned gender gap in STEM begins to manifest itself at an early age and worsens during adolescence. This is why in this study a comprehensive research was carried out to analyze the factors that contribute to the gender gap in STEM careers. This allowed the identification of effective measures to increase women's participation in these fields. One of the suggested solutions is the implementation of practical workshops, in which female figures play a key role. These workshops are used to demonstrate students that there are numerous role models nearby who can motivate and encourage them to explore and develop their interest on the field of science and technology. By providing said opportunities and role models, our aim is to build their confidence and confidence, and provide them with the necessary tools to take advantage of all the opportunities that the STEM field has to offer.**

***Keywords*— gender gap, STEM vocations, Maker Education, female role models**

I. Introduction

Nowadays, women's equality in all fields of society is positioned as one of the main objectives of organizations and governments. Some of the most important seek to promote gender equality and women's empowerment through different initiatives to achieve the Sustainable Development Goals (SDGs) [1].

Many advances have been achieved in recent years, but the situation may differ from country to country and from one sector of society to another. Especially in the STEM (Science, Technology, Engineering and Mathematics) professions, the participation of women remains low [2]. This gap is particularly related to factors that represent barriers to achieving gender equity in STEM fields. These may include a lack of exposure to them, the presence of gender stereotypes based and biases, as well as the influence of relatives and partners [3]. To promote the presence of women in scientific careers, it is necessary to adopt an inclusive educational and professional perspective free of gender biases. One effective way to do this is to include female references in the curricula, in order to diversity the studied figures [4].

II. Teaching in the 21st century

The 21st century has had a significant impact on people's lifestyles due to technological changes, which has influenced the transformation of young and adult society. In the educational field, these changes have generated the need to explore new paradigms, where technologies present innovative challenges in teaching, as is the case of the STEAM approach or methodology. This acronym is the evolution of STEM, where the A refers to the virtues of design and art with all its aspects, such as critical and creative thinking [5].

As education seeks new strategies to prepare students to become successful professionals in today's job market, more attention is being paid to STEAM and related learning methods. Contrary to traditional teaching methods, the STEAM approach erases the boundaries between disciplines to solve problems and promote higher levels of creativity and efficiency [6].

Therefore, the present study analyzes the lack of STEM vocations and evidences the most important factors that induce it. It also shows the importance of including female references in the curricula to diversify the figures studied and to use young female teachers to teach workshops related to these disciplines [7].

A. Maker Education

Maker Education comes from the Maker movement, which is an approach to learning based on practical experience and community collaboration. At present, this movement has moved to educational contexts, seeking its integration in both secondary schools and universities. In general terms, the objective of Maker Education is that students apply the principles of design to develop ideas and build prototypes, using several design and fabrication tools [8]. This provides opportunities for young people to develop confidence, creativity and interest in the field of STEAM through creating [9], while encouraging academic learning through teamwork, problem solving and experimentation.

III. Gender gap in STEM field

Recent years have seen a decline in student's interest in STEM education despite the growing need for professionals in these areas. In addition, especially in the context of most engineering degrees, there is a gender gap in these disciplines, where the number of women who enter is very low [10].

A. Reasons for rejection

The impostor's phenomenon and fear of failure influence the low participation of women in STEM [11]. This imposter phenomenon negatively affects students' self-efficacy, especially in women, which may explain why some of them avoid studying STEM fields [12]. In addition, it has been observed that women may experience the impostor phenomenon from an early age [13].

B. Female role models

One of the causes of female students' lack of interest in STEM subjects is gender stereotypes. The way to combat these widespread beliefs is by presenting female role models

in STEM-related areas in the classrooms. According to several studies, female students have better self-esteem when they have positive female role models. Likewise, providing female role models increases girls' curiosity and empowers them with the skills they actually have to pursue STEM careers in the future [14].

C. *Influence of the surrounding environment*

To understand the lack of STEM vocations, the literature suggests that students' motivation may be influenced by various factors. For instance, the choice of career is one of the most transcendental decisions in a person's life, since it is the moment when the path to follow is determined and is also motivated by such factors. Among these, a relevant element is the impact of their environment, such as family support, the presence of STEM models in the family or the involvement of parents and teachers to motivate them towards STEM disciplines [15].

IV. Study of STEM vocations

In order to investigate the lack of STEM vocations among high school students, a study was undertaken. This study uses as its instrument a 45-question survey based on the "*Encuesta sobre la percepción de barreras y apoyos en la elección de estudios STEM dirigida a estudiantes de secundaria*" (Survey of perceived barriers and supports in the STEM studies choice addressed to high school students) [16]. Also, the target audience were students from 2nd course of secondary education to 2nd course of Baccalaureate.

This study had its background in a previous research related to the project "*Acércate a la ingeniería*" (Get closer to engineering) from which we were able to obtain some initial data that showed the present crisis in STEM disciplines and that gave rise to further study in this field. In this research, a survey with a pretest and posttest design was used as an instrument. First the Pre Test was conducted to see the starting point of the students and after that the project was carried out, where the students did various activities to learn firsthand about engineering and what is related to it. At the end of the experience, the questionnaire (Post Test) was repeated to see the impact that the project had on the students, and it was here where interesting data were obtained.

Thanks to this design it was possible to observe how the percentages in some of the questions tended to be more negative, because they knew firsthand the relative difficulty involved in engineering degrees and therefore, they responded with greater criteria reflecting that they did not consider they had the skills to be able to successfully face this type of degree. Despite these results, regardless, the experience resulted in an increase in both genders, mainly in the case of female students, in wanting to study university degrees and specifically degrees in the field of engineering. Therefore, these results indicated that there was still a lot of work to be done in terms of motivation, especially in the case of female students, to make them understand that they possess the same capabilities and potential as their male peers.

Now turning to the study being presented, in this case, a sample of 1018 respondents was obtained, with an equal distribution between the different genders. With the results obtained, a detailed analysis was made of the 5 blocks that included the different questions, where the first one was used to make relationships between blocks since it dealt with sociodemographic data. The most relevant results are shown below:

A. *Block II: Tastes*

In the second block, which deals with tastes, in a generic way, all students reflected having had toys related to construction, cars, etc. However, if we analyze what type of toys each one used in childhood, in the case of female students, dolls, skateboards or puzzles prevailed, while in the case of male students, balls, scooters/motorcycles and Legos were the most popular. This is reflected in the response of 33% of the students who indicated that toys by gender do exist.

In addition, with respect to the use of free time, although both genders agree that they prefer to listen to music and meet with friends, and in the case of male students, they have a much higher percentage in terms of playing sports and video games.

B. *Block III: STEM supports*

The third block analyzes the support received by students with respect to the STEM field. Here it was observed that, in the case of both male and female students, the percentage of those who have been taken to STEM activities by their parents was 40%, while 60% indicated not having had this experience. On the other hand, they felt that their teachers encourage them to participate in STEM activities, especially teachers of subjects such as technology. In particular, 74% of male students reported receiving support from teachers in this regard, compared to 67% of female students.

Likewise, student participation in STEM extracurricular activities, family support for such activities and the support received by teachers were also analyzed. This can be seen in Fig. 1.

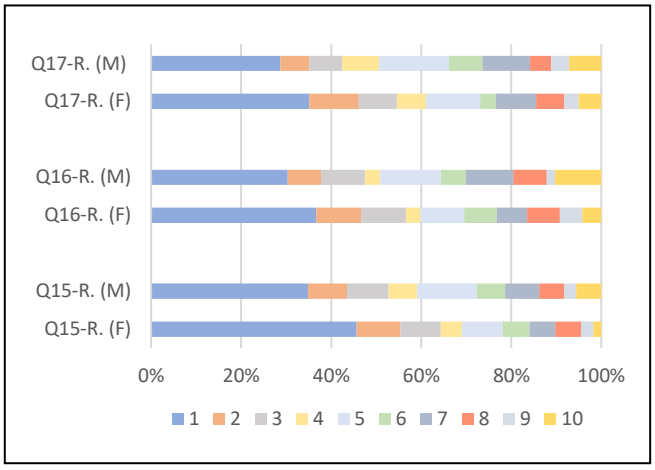

Fig. 1. Chart on extracurricular STEM activities.

In this case, practically 50% of the sample in both genders is placed between values 1 and 4, on a scale from 1 to 10 (being "1" very little and "10" a lot), so they neither participate in this type of activities voluntarily, or consider that their closest referents such as family and teachers encourage them to do it.

C. *Block IV: STEM opinion*

On the other hand, the fourth block allows us to know the students' opinion regarding the STEM field. This block shows a clear gender bias, with 53% of female students preferring sociolinguistic subjects, compared to 35% of male students, who show a preference for more technical subjects (Fig. 2).

However, it is the female students who clearly decide to continue their academic studies, with 97% compared to 88% of their male peers, and with the same difference in terms of wanting to study a university degree versus a vocational training course. However, when asked if they want these studies to be related to the STEM field, the percentage is interchanged, with male students preferring to link their studies to this field, as some of them reflect that this type of degree is more suitable for the male gender.

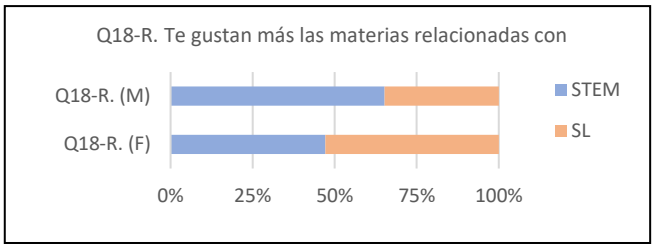

Fig. 2. Chart on predilection by subject type.

We wanted to analyze their uninterest towards these types of disciplines, especially in the case of female students, and the results seemed to indicate that, in both genders, the two main issues that influenced the decision not to opt for this type of degree are personal capacity and lack of interest, with the percentage being slightly higher in the case of female students (see Fig. 3). An aspect that also has some influence, although to a lesser extent, is the perception that these degrees are not valuable to society. This concept possibly arises from the students' lack of knowledge about this field.

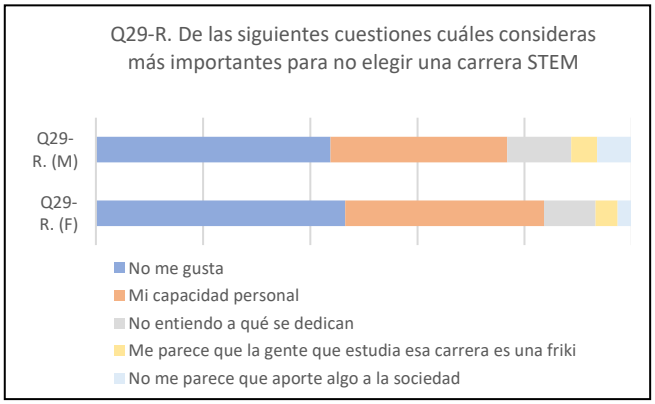

Fig. 3. Chart on the main reasons for not pursuing a STEM degree.

D. Block V: STEM role models

The last block analyzes the students' role models. It is reflected that both male and female students do not feel that their colleagues encourage them to study science; in addition, female students emphasize that their closest friends do not think it is good for them to study science.

However, both genders see their teachers as the closest role models working in the STEM field.

Likewise, in both cases, the students evidenced that they had no knowledge of current famous role models, much fewer female ones, indicating only old ones such as Albert Einstein, Marie Curie or Tesla.

E. Relationship between blocks

As previously mentioned, the first of the blocks has been used to make several comparatives between the different blocks and questions.

Among the different comparatives carried out, some data were highlighted, such as the predisposition to study STEM degrees of those students whose fathers and mothers had higher education, such as degree or master's degrees, especially in the case of female students whose mothers had such studies.

It was also observed that in public schools, male students are more interested in the more technological subjects, compared to female students, in which case the percentage is evenly distributed, but in private concerted schools, the percentage of female students is much higher in sociolinguistic subjects.

On the other hand, the type of study (university degree/vocational training cycle) was compared with the possible relationship in the STEM field. Once again, the male students showed an outstanding interest in the STEM field in both types of studies. As for the female students, they only reflected this in the case of university studies in a small percentage, with the opposite occurring when they wished to pursue vocational training cycles, as shown in Fig. 4.

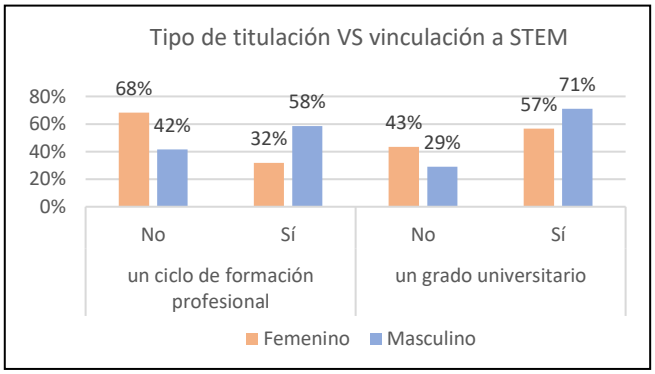

Fig. 4. Chart comparing the type of degree and its linkage to STEM field.

Finally, among the most relevant data found in the comparative studies is the relationship between playing video games and wanting to pursue STEM studies, where there is a clear gender bias. The entirety of the sample of male students who played indicated that they wanted to pursue STEM studies, compared to only half of the sample of female students.

V. Practice Experience

To address this lack of STEM vocations, a hands-on workshop was held in "Las Cocinas" space where numerous practical activities were carried out to demonstrate Maker Education. Students applied the principles of design to develop ideas and build prototypes, using different design and manufacturing tools, experimenting and working in teams. Likewise, in order to increase these female role models, several teachers led the different activities of these workshops.

Likewise, after analyzing the survey data and observing in the literature the need to act at earlier stages, this experience was worked with a group of 3rd and 4th grade students. In this workshop, some subtle questions were asked to analyze whether the imposter syndrome existed, and it was discovered that the female students preferred technological subjects and saw themselves as very skilled in this field. However, their peers reflected that they considered them to be worse than them when it came down to doing things related with technology.

This mindset can carry over into future courses and female students may begin to reject the STEM field because of it, so it is a first touchstone that illustrates a field to study.

Nevertheless, the experience turned out to be very enriching, as the students gave their feedback with numerous messages where they seemed to indicate that these workshops had a positive impact in that fostering of STEM vocations.

VI. Conclusions

To finalise, this work highlights the general lack of motivation of students, especially girls, to pursue careers in STEM fields.

In addition, it has been observed that almost half of the student sample does not receive support from family members or teachers to pursue studies in STEM fields. This critical data requires further analysis and the implementation of solutions because close role models have a significant impact on students' future academic decisions.

The importance of role models has become evident for both genders, but especially for female students. Having someone to look up to close who motivate and show them that they have the necessary attitudes and aptitudes is fundamental to encourage female students to continue studying what they like to do.

Likewise, it has been found in the literature and in the pilot experience with elementary school students that it is essential to encourage STEM vocations from earlier stages. At the secondary school stage, where gender bias is already very present, it may be more difficult to change the ingrained concepts in students, such as the imposter syndrome associated with the perceived lack of ability to face careers in this field.

To conclude, after participating in the workshops, a considerable percentage of the students showed a higher interest in pursuing university studies and considered the possibility of studying STEM careers in the future, especially in the case of female students.

Acknowledgment

This project has been partially funded by the co-edu research project “Competencias transversales desde la EIIC para su ecosistema social”, granted to the ULPGC for Fundación CajaCanarias y Fundación LaCaixa. Also, by the Education Department of the Canary Islands government.

We would also like to thank the authors Álvarez and Lanchares for providing us the questionnaire used in this study, which allowed us to obtain interesting results.

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