The Challenge of the Gender Gap and the Lack of STEM Vocations in ESO and Baccalaureate

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***Abstract*— The persistence of gender inequality in STEM careers among high school students represents a significant and ongoing concern. A decline in interest in science and technology, particularly among female students, is a notable finding in the research. From an early age, this disparity intensifies, prompting a comprehensive examination of the factors that perpetuate it. This study examined strategies to enhance female involvement in STEM, with a particular focus on hands-on workshops where women assume a pivotal role. These workshops aim to inspire and motivate students by showcasing examples of successful women in STEM, while also fostering their confidence and empowerment. The methodology encompassed surveys of middle and high school students, which revealed that nearly half of the students lacked familial or pedagogical encouragement to pursue STEM careers, underscoring the pivotal role of close role models in academic decisions. Furthermore, a comparative analysis was conducted to examine the discrepancies between students from private/subsidised and public educational institutions. The findings emphasise the necessity of initiating vocational guidance at an early stage of development, thereby counteracting the biases that are often established during adolescence, such as the impostor syndrome. Following their participation in the workshops, a notable proportion of students indicated an enhanced interest in pursuing university studies in STEM, with female students reporting heightened motivation and empowerment to explore these career pathways. This approach aims not only to equip young women with the requisite tools for success in STEM, but also to inspire a new generation of women leaders in science and technology.**

***Index Terms*— Communication engineering education, female role models, gender gap, pre-college engineering, STEM.**

I. Introduction

NOWADAYS, many organizations and governments prioritize the pursuit of gender equality in all spheres of society. Leading organizations strive to promote gender equality and women's empowerment through various initiatives aimed at achieving the Sustainable Development Goals (SDGs) adopted by the United Nations General Assembly [1].

Although much progress has been made in recent years, there are still differences in the situation between countries and sectors of society. In particular, in STEM (*Science, Technology, Engineering and Mathematics*) professions, female participation remains low [2]. This gap is particularly linked to factors that act as barriers to achieving gender equality in STEM fields. These factors that hinder women's participation in STEM careers include lack of exposure, gender stereotypes and biases, and influence from parents and peers [3]. To promote gender equality in scientific careers, it is necessary to adopt an inclusive and gender-neutral approach in education and the workplace. One effective strategy is to include female role models in curricula in order to dismantle stereotypical images that limit women's career choices [4]. Despite significant advances and research in the field of gender equality education, the didactic materials often used in fourth-year secondary education classrooms do not adequately reflect the interest shown by educational administrations in this area. This is evident when analysing curricula, textbooks, and consulting teachers' opinions [5], [6]. Therefore, it is essential to make changes and adaptations to the curricula to include more female figures and revalue the areas and tasks traditionally associated with them. This can be achieved by implementing a system of evaluation and assistance by publishers to ensure the creation of teaching materials committed to equality, both in content and language [5].

As the discussion of gender inequality in STEM deepens, it is vital to recognise that this issue has ramifications that extend beyond the individual woman. It also has broader implications for society.

Ensuring gender equality in STEM fields is not only a matter of fairness and equity; it is also a means of achieving broader societal goals. The involvement of women in research and innovation activities is of paramount importance in addressing the current global challenges, including climate change, public health and sustainable technological development [7]. The diverse and unique perspectives that women bring to these endeavours are invaluable in formulating effective solutions to these pressing issues. It can be reasonably argued that the promotion of gender equality in STEM will result in significant advances that will benefit society as a whole.

This paper investigates the gender gap in STEM interest among secondary and high school students, as a follow-up to the paper presented at the XII International Conference on

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Virtual Campus (JICV 2023) conference titled "*The gender gap in Secondary and High School Students in STEM fields*" [8]. The accumulation of evidence suggests a lack of attraction to the scientific-technological field in both genders, with a greater lack of interest observed in females. This has led to an increase in research on students' STEM perspectives. Furthermore, this study includes an analysis of the disparities between students in private/chartered and public schools.

The study aims to analyse the factors contributing to young people's rejection and address them through practical solutions in the educational environment and complementary activities where Maker Education is applied. It also seeks to demonstrate the feasibility and, in some cases, the recommendations of these proposals from an early age, highlighting the design of the activities as learning tools focused on the teaching and learning of engineering.

II. Education in the 21st Century

The 21st century has brought about significant lifestyle changes, driven by technological advances that have impacted the evolution of both youth and adult society. In the field of education, these changes have created a need to explore new paradigms. Technology presents innovative challenges in the field of teaching, such as the STEAM approach or methodology. This term is a development of STEM, where the new 'A' represents the values of design and art as a whole, encompassing critical and creative thinking [9]. The worldwide perspective of STEAM suggests that it enables the acquisition of transversal competencies and soft skills in an applicable context [10]. The proposition is put forth that STEAM can facilitate creativity and innovation through the synergistic interaction between thinking in the arts and sciences [11].

Education is currently facing challenges due to the specificities of an information society. This urges us to reflect on the role of education in the knowledge society and the type of individuals that the 21st century society requires [12].

To prepare students and equip them with the skills needed to excel in today's labour market, education seeks to develop new strategies. There is a growing interest in approaches such as STEAM and related learning methods. In contrast to traditional educational methods, the STEAM approach blurs disciplinary boundaries to address problems holistically, promoting greater creativity and efficiency [13].

Future projections suggest that the STEAM domain, particularly in Engineering and Technologies, including the Internet of Things, Big Data and Artificial Intelligence, is undergoing a significant transformation that will have a substantial impact on our society and employment landscape. This revolution is characterized by rapid digitalization [14]. As a result, there will be a need to educate students who are prepared to learn and develop 21st century skills. In order to effectively integrate into the work and social environment and adapt to the demands of this new era [15], skills such as communication, critical thinking, creativity, and collaboration are essential.

A number of case studies offer valuable insights into the implementation and efficacy of STEAM methodology in educational settings. A study conducted in a kindergarten in Sungai Rumbai demonstrated the efficacy of integrating STEAM activities into the curriculum for children aged 4-5 years. This approach was observed to enhance problem-solving abilities and facilitate the integration of diverse scientific disciplines [16]. Similarly, another study involving pre-school teachers using LEGO educational tools demonstrated the benefits of STEAM education, including the development of teamwork, problem-solving and active participation skills, which illustrate the practical applicability of this innovative methodology [17]. Moreover, the influence of blended task-based pedagogical approaches in STEAM curricula was investigated, underscoring the significance of task design in enhancing academic achievement and problem-solving abilities. One illustrative example of this research is an intelligent monitoring project for wooden arch bridges [18]. When considered collectively, the case studies demonstrate the beneficial impact of STEAM education on children's motivation, engagement, creativity and skill development.

It is important to note that despite efforts towards more holistic approaches, such as the STEAM paradigm, many educational settings have not yet fully adopted this methodology. The practical application of including the Arts in STEAM methodology has faced considerable resistance and challenges, despite its undeniable contribution in fostering creativity and critical thinking [19]. Furthermore, a significant limitation is the lack of effective tools to quantify and evaluate specific aspects within the STEAM domain. Existing metrics and assessments often focus exclusively on STEM disciplines, excluding the valuable contribution of the Arts [20].

In this context, the article focuses on STEM, acknowledging the current limitations in fully integrating the Arts.

Maker Education in the field of education is derived from the Maker movement, which is an educational approach centred on hands-on experience and community collaboration. Nowadays, Maker Education has been integrated into educational environments, aiming to incorporate it into both secondary education institutions and universities. The approach proposes that students apply design principles to develop ideas and build prototypes using a variety of design and fabrication tools [21]. This approach provides opportunities for young people to cultivate confidence, creativity and interest in STEM fields through the creative act [22]. At the same time, it promotes academic learning through team collaboration, problem-solving, and experimentation [21].

III. Gender Gap in STEM Field

STEAM education initiatives seek to address diversity gaps, including the gender gap, by integrating elements of fabrication labs, multimedia labs, and user labs to engage under-represented groups [23].

Moreover, research has indicated that while attitudes towards STEM fields may not differ significantly by gender, interest in STEM careers does exhibit variations, with male students demonstrating a greater inclination towards engineering and technology fields compared to their female counterparts [24]. Indeed, in recent years, there has been a decline in student interest in STEM disciplines, despite the growing demand for professionals in these fields. Specifically, in the context of engineering, a significant gender disparity has been identified, as reflected in the low participation of women [25].

The gender gap in STEM studies is influenced by myths, misbeliefs, and misrepresentations, as well as by various factors internal and external factors such as the social and family environment [26]. This phenomenon is evident in the '*Leaky Pipeline*', where women tend to lose interest in STEM studies as they age [27]. The concept of a 'leaky pipeline' refers to the phenomenon whereby underrepresented groups, particularly women, encounter barriers and cease their progression at various stages of their careers in fields such as academia and STEM, which results in a decline in their representation in senior positions [28]. In order to address this issue, it is necessary to recognise and rectify biases, promote inclusion and provide support in order to retain diverse talent in these fields.

It is important to note that the aversion to STEM disciplines is often attributed to the impostor phenomenon and fear of failure, which significantly contribute to the limited participation of women in STEM [29]. The impostor phenomenon negativelly affects students' self-efficacy, particularly among females, which partly explains why some avoid pursuing STEM fields, as reflected in the authors' research by Jöstl et al. and Nelson et al. [30], [31]. Furthermore, research has shown that women may experience the impostor phenomenon from an young age [32].

A. Impact of the Immediate Context

To tackle the shortage of STEM vocations, the literature suggests that students' motivation may be influenced by various factors. Once crucial aspect is the impact of the environment, which includes family support, the presence of STEM role models in the family, and the active involvement of parents and teachers in stimulating interest in STEM disciplines [33].

Competent teachers and parents have a significant influence on students' decision-making regarding STEM careers. Research has shown that women who choose to study in STEM fields are particularly influenced by their mothers and some educators [34].

B. The Role of Female Models

Gender stereotypes contribute to female students' disinterest in STEM disciplines. The way to counteract these generalized perceptions is to introduce female role models in STEM-related fields into the educational environment. Several theories support this educational strategy. From the perspective of Bandura's social learning theory [35], learning occurs in a social context through the observation of role models; by seeing women succeed in STEM, students internalize behaviors and attitudes that strengthen their self-efficacy, which is essential to their perception of viability in these careers. Similarly, gender role identity theory emphasizes that female role models broaden the range of aspirational roles for girls, reducing dissonance between their gender identity and their potential career development in traditionally male fields [36].

Several studies have found that female students experience an improvement in self-esteem when they have positive female role models. Exposure to female role models not only stimulates girls' curiosity, but also strengthens the skills they possess to enhance possible STEM careers in the future [37].

Furthermore, uncertainty is a significant barrier for adolescent girls, so it is essential to provide a clear understanding of STEM careers, highlighting their impact on humanity and the social dimension of technology, in order to motivate them to choose these careers [38]. It is also crucial to emphasize that mentoring programs and early exposure of girls to role models have a significant impact on their self-confidence and the choices they make in their personal and professional development [39].

IV. Analysis of Interest in Science and Technology Among Secondary and High School Students: An Emphasis on STEM Vocations

To tackle the shortage of STEM vocations among secondary school students, a study was conducted using 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*" [40].

The questionnaire forms part of a research project whose aim is to analyse the perceptions of secondary school students with regard to science and technology careers and disciplines. The principal objective is to identify the barriers and supports that influence the decision to embark upon a STEM-related course of study, and to examine how these influences vary according to different variables, such as gender [40].The construction of the questionnaire was informed by a systematic review of the scientific literature on the perception of STEM disciplines among young people, which enabled the items to be formulated with precision and a robust evidence base.

Following the formulation of the questions, the questionnaire was subjected to a validation process involving the input of three experts in the fields of education and gender studies. These experts were tasked with assessing the relevance and coherence of the questions. This feedback was instrumental in the finalisation of the questionnaire. Once administered, the reliability of the questionnaire was assessed using Cronbach's alpha coefficient, a widely recognised method for determining the internal consistency of a questionnaire [41], [42].

As well, this questionnaire was reviewed by experts in education, language, and gender, and underwent a statistical validation process. Furthermore, this methodology has been utilised in other studies that analyse barriers, supports, and the gender gap in STEM education at the secondary level. These studies, as well as ours, seek to understand the reasons behind the underrepresentation of women in STEM fields and provide valuable information to promote diversity and inclusion in STEM education [14], [43].

In this case, this study is a continuation of a previous investigation linked to the Project "*Acércate a la ingeniería*", which provided initial data showing the crisis in STEM disciplines.

This motivated the need for a more detailed study in this area. In that project, unlike this study, a survey was conducted using a Pre-test and Post-test design. The Pre-test was used to evaluate the students' initial knowledge, followed by a project implementation phase where students participated in various activities to gain practical understanding of engineering and related topics. At the end of the experience, we administered the Post-Test questionnaire again to evaluate the project's impact on the students. We obtained data of interest at this stage of the study.

This design reveals that some of the questions had a more negative perception. This was due to the direct knowledge of the relative difficulty associated with engineering degrees, which led to more reflective responses indicating a perception of not having the necessary skills to successfully undertake this type of academic programme. Despite the unfavourable results, the experience increased the interest of both genders, particularly female students, in pursuing university degrees, especially in the field of engineering. These results indicate a continuing need for motivation, particularly for female students, to recognise their skills and potential compared to their male peers.

The study focuses on a sample of 975 students from 2nd ESO to 2nd Baccalaureate, attending schools located in the various islands that make up the Canary Archipelago (Canary Islands, Spain).

The selection of this group is based on the central objective of the study, which is to obtain a comprehensive understanding of vocations in STEM areas in the Canary Islands and to assess possible gender differences in these disciplines. It is therefore crucial to ensure that the sample is representative of the geographical and demographic diversity of the student population in the archipelago.

To obtain this sample, a number of schools in the various islands of the Canary Islands were contacted via both institutional mailings and direct communications with the schools. Special consideration was given to the inclusion of schools from diverse geographical locations, with representation from both capital and non-capital islands. This approach ensures the representativeness and validity of the study's results, as it encompasses the diverse range of educational contexts present in the Canary Islands. The survey was conducted online, without the need to register, in order to maintain anonymity through the teachers of the different classes in the centers.

To conduct this analysis, it is essential to consider the minimum representative sample. Cochran's equation [44] with finite population correction describes the sample size (n) given a target confidence level, a margin of error (ε), a population proportion (p) and a population size (N).

The population for the aforementioned courses during the 2022/2023 academic year was 65,000 [45]. With a confidence level of 95% (equivalent to a score of 1.96), a margin of error of 5%, and an assumed population proportion of 50%, a minimum sample size of 382 participants is required to ensure representativeness. The questionnaire designed for this study was completed by a sample of 975 individuals, exceeding the minimum required for a 95% confidence level by 593.

The results were used to conduct a comprehensive analysis of the five dimensions present in the survey. The statistical analysis was conducted using the Jamovi software [46], [47], with a 95% confidence level applied in all cases. The results of the Shapiro-Wilk tests indicate that the data collected do not exhibit a normal distribution, and thus require the application of non-parametric statistical tests.

In the descriptive phase, the primary focus is on exploratory analysis. The objective of the descriptive statistics is to analyse the principal results obtained from the questionnaire, quantifying the response frequencies.

The following section presents a concise overview of the most pertinent aspects of each dimension and their interrelationships, as well as some interrelationships between them. This is done in response to the research questions that were posed during this study.

A. Dimension I: Socio-Demographic Aspects

This dimension describes the distribution of students by level of education, type of centre and parents' education. The sample is representative, with 39.1% in the 2nd ESO, followed by the 4th ESO (28.5%) and other levels in smaller proportions. Most students (90.9%) attend public schools, while 8.7% attend charter schools. In addition, a higher percentage of mothers than fathers are enrolled in university or postgraduate studies, although both have similar numbers in secondary and vocational education.

B. Dimension II: Preferences

In the second dimension, which deals with preferences, in general, all students indicated having had toys related to construction and cars, among others. h dolls, skateboards, or puzzles, while male students preferred balls, vehicles/motorbikes, and Legos. The data shows that 33% of students believe that toys should be divided by gender.

Additionally, both male and female students prefer listening to music and socialising with friends during their free time, but male students have a significantly higher preference for playing sports and video games.

C. Dimension III: STEM Supports

The study's third dimension examines the support given to students in STEM. The results show that 40% of both male and female students participated in STEM activities with parental support, while 60% did not have this experience. Furthermore, students reported that their teachers encourage them to participate in STEM activities, especially those who teach technology-related subjects. More specifically, 74% of male students reported receiving support from their teachers in this regard, compared to 67% of female students.

The study also analysed students' participation in extracurricular STEM activities (Q15), as well as family and teacher support for such activities (Q16 and Q17), as shown in Fig. 1. The results indicate that approximately 50% of both male and female students rated their support level between 1 and 4 on a scale of 1 to 10 (with '1' indicating very little and

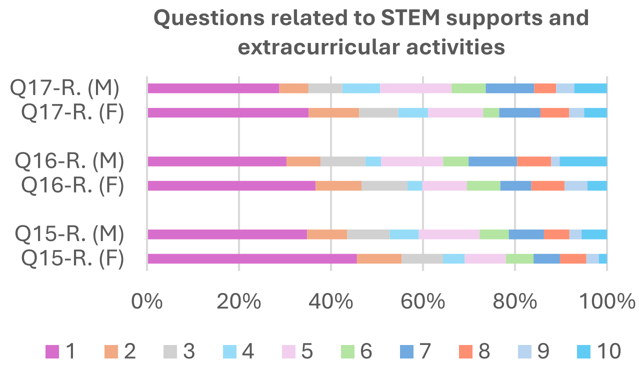

Fig. 1. Exploratory Graph of Support for STEM Extracurricular Activities. (F) = female, (M) = male.

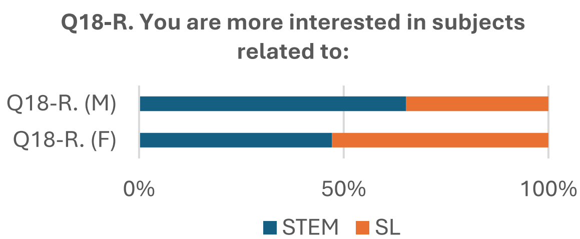

Fig. 2. Graph on Preference by Type of Subjects. (F) = female, (M) = male, SL = Sociolinguistic.

TABLE I

CONTINUITY IN STUDIES. DISTINCTION BY GENDER

Q01. Gender		Q20-R. Do you want to continue studying when you finish ESO/Baccalaureate?		
		No	Yes	Total
F	N	**19**	492	511
	%	**3.7 %**	96.3%	100.00%
M	N	**54**	410	464
	%	**11.6 %**	88.4%	100.00%
T	N	73	902	975
	%	7.5 %	92.5%	100.00%

F = female, M = male, T = total, N = sample

'10' indicating very much). This suggests that there are many students who do not voluntarily participate in such activities and do not perceive that their closest referents, such as family and teachers, motivate them to do so.

D. Dimensión IV: STEM Perspectives of Students

The fourth block presents students' opinions on the STEM field, revealing a gender bias. According to the data, 53% of female students prefer sociolinguistic subjects, while only 35% of male students do (Fig. 2).

However, there is a statistically significant difference ($p < 0.001$) in the clarity of academic continuation between male and female students. Only 3.7% of female students indicate that they do not wish to continue studying after completing the baccalaureate, compared to 11.6% of male students (refer to Table I).

TABLE II

TYPE OF TRAINING. DISTINCTION BY GENDER

Q01. Gender		Q21-R. If you answered yes, would you like to study:		
		CFFP	GU	Total
F	N	**104**	381	511
	%	**21.4 %**	78.6%	100.00%
M	N	**137**	290	464
	%	**32.1 %**	67.9%	100.00%
T	N	241	671	975
	%	26.4 %	73.6%	100.00%

F = female, M = male, T = total, N = sample, CFFP = vocational training cycle, GU = university degree

TABLE III

TYPE OF TRAINING. DISTINCTION BY GENDER

Q01. Gender		Q23-R. Do you believe that careers in Technology or Science are more:			
		both	girls	boys	Total
F	N	503	1	**7**	511
	%	98.4 %	0.2%	**1.4%**	100.00%
M	N	432	2	**30**	464
	%	93.1 %	0.4%	**6.5%**	100.00%
T	N	241	3	37	975
	%	95.9 %	0.3%	3.8%	100.00%

F = female, M = male, T = total, N = sample

A significant difference is observed in relation to the choice between studying a vocational training course or a university degree. The data shows that 32.1% of male students choose vocational training courses, compared to 21.4% of female students ($p < 0.001$), as illustrated in Table II.

However, when asked about their preference for the subject matter of these studies, the results are reversed, with male students showing a greater inclination towards STEM fields.

When exploring the perception of whether science and technology careers are more appropriate for boys or girls, 6.5% of males consider them more suitable for boys (30 out of 464), compared to 1.4% of females (7 out of 511), creating a statistically significant relationship ($p < 0.001$) (refer to Table III).

Within this same section, there was an interest in analysing the reasons behind the lack of interest in these disciplines, particularly among female students. The results indicate that the two most influential factors in the decision not to pursue these degrees are the perception of personal ability and lack of interest, with the percentage being slightly higher among female students (refer to Fig. 3). Another factor that may have some impact, albeit to a lesser degree, is the perception that these degrees do not contribute to society. Possibly, students' lack of knowledge in this field could explain this concept.

This is reflected in future career aspirations, where in the case of female students, there is a strong interest in the health field, as well as in social areas such as law, psychology and education. Some female students also show interest in more artistic fields such as art or architecture. However, there are no mentions of engineering-related careers.

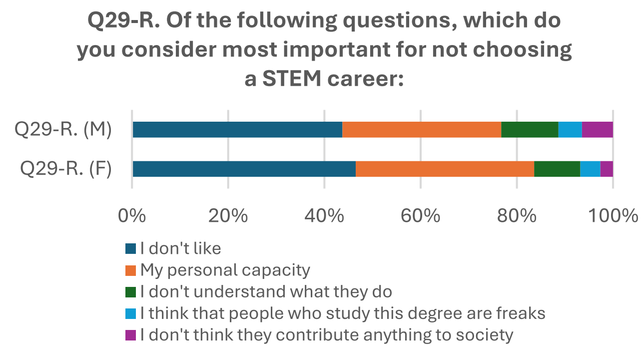

Fig. 3. Graph on reasons for not choosing STEM degrees. (F) = female, (M) = male.

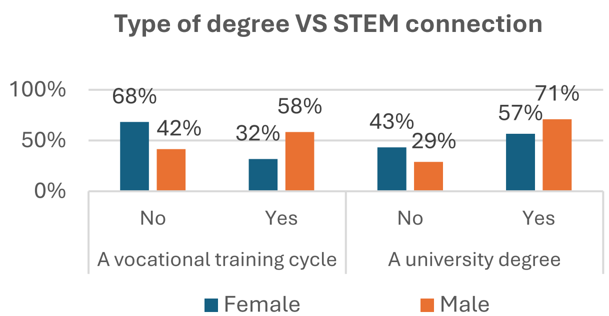

Fig. 4. Chart on types of degrees and their link to the STEM field.

In contrast, many male students express interest in technical careers such as computer, chemical, or aerospace engineering. The remaining students come from fields related to sports, vocational training courses related to mechanics, and professions in law enforcement and security forces. In contrast, the sociolinguistic field is less popular among male students, indicating a clear difference in study preferences between genders. As academic progression continues, there is a noticeable trend of female students rejecting scientific and technological fields. This trend reflects the concept of 'escape conduct' mentioned earlier in this paper.

Additionally, we aimed to investigate the aspects that female students consider important or interesting when choosing a technical degree. According to Figure 4, the most important factors were the potential for high income, opportunities for employment, the ability to contribute to society, and the opportunity to help others. Both genders rated prestige as less important.

E. Dimension V: STEM References

do not feel encouraged by their peers to pursue science studies. Additionally, female students report that their closest friends do not view it positively for them to choose careers in this field.

Conversely, both male and female students identify their teachers as the primary role models working in the STEM field.

Regarding famous role models, students indicate a lack of knowledge about contemporary figures, particularly women. They only mention historical figures such as Albert Einstein, Marie Curie, and Tesla.

F. Relationship Between Dimensions

As previously stated, the first dimension was used to carry out various comparisons between the different dimensions and their respective questions.

Notably, data highlighted a correlation between students whose parents held higher education degrees, specifically bachelor's or master's degrees, and their inclination to study STEM subjects. This correlation was particularly evident among female students whose mothers held such degrees.

The study compared the type of education (university degree/training cycle) with the potential connection to the STEM field, answering the question "How does interest in the STEM field vary between undergraduate and graduate students, and how does gender influence these differences, especially in the case of female students who opt for university versus vocational training? Male students showed a strong interest in the STEM field in both types of education, while female students only expressed this interest in the case of university studies, in a small percentage. This trend is reversed when female students express interest in vocational education and training, as shown in Fig. 4 below.

Furthermore, the study conducted a comparison between public and private schools, analysing the similarities and differences. For that, the following questions were asked: How do differences between public and private schools influence students' interest in technological and sociolinguistic subjects, and how does this interest vary between male and female students? What factors could explain the difference in the intention to continue studies after ESO/Bachillerato between students from public and private/concerted schools, considering the statistical significance observed?

The results showed that students in public schools exhibit a greater interest in technological subjects, while the percentage is evenly distributed among female students. In contrast, private schools have a significantly higher percentage of female students interested in sociolinguistic subjects.

Subsequently, the desire to continue studies after ESO or Baccalaureate was examined. Although the sample of students in public schools (906) is significantly larger than that of students in private/concerted schools (69), it is noteworthy that 100% of students in private/concerted schools intend to continue studying at the end of ESO/Baccalaureate, compared to 91.94% of students in public schools. This difference in proportions is considered statistically significant ($p = 0.014$), as shown in Table IV below.

The study examined the preferred type of study among students who expressed a desire to continue their education. It is worth noting that 27.9% of students in public centres expressed interest in pursuing a vocational training cycle, compared to only 8.7% of students in private/concerted centres, as shown in Table V.

The variable was then employed to prompt the following question: The objective was to ascertain the relationship between the type of school selected and the father's level of education, and to determine how these variables vary between university, secondary school and primary school. We found a significant difference ($p = 0.004$) between the types of

TABLE IV
CONTINUITY OF STUDIES. DISTINCTION BY TYPE OF CENTRE

Q05.1-R. Type of centre:		Q20-R. Do you want to continue studying when you finish ESO/Baccalaureate?		
		No	Yes	Total
Private subsidized	N	0	**69**	69
	%	0.0 %	**100.00%**	100.00%
Public	N	73	**833**	906
	%	8.1 %	**91.9%**	100.00%
Total	N	73	902	975
	%	7.5 %	92.5%	100.00%

N = sample

TABLE V
CONTINUITY OF STUDIES. DISTINCTION BY TYPE OF CENTRE

Q05.1-R. Type of centre:		Q21-R. If you answered yes, would you like to study:		
		CFFP	GU	Total
Private subsidized	N	104	381	511
	%	21.4 %	78.6%	100.00%
Public	N	137	290	464
	%	32.1 %	67.9%	100.00%
Total	N	241	671	975
	%	26.4 %	73.6%	100.00%

CFFP = vocational training cycle, GU = university degree, N = sample

TABLE VI
TYPOLOGY OF CENTRE. DISTINCTION BY PARENTAL EDUCATION

Q05.5. Mother's studies:		Q05.1-R. Type of centre:		
		Private	Public	Total
EP	N	**3**	**97**	100
	%	**4.3 %**	**10.7%**	10.3%
ES	N	**9**	**228**	237
	%	**13.0 %**	**25.3%**	24.3%
FP	N	15	155	170
	%	21.7 %	17.1%	17.4%
N	N	1	25	26
	%	1.4%	2.8%	2.7%
X	N	14	203	217
	%	20.3%	22.4%	22.3%
P	N	1	25	26
	%	1.4%	2.8%	2.7%
U	N	**26**	**173**	199
	%	**37.7%**	**19.1%**	20.4%
Total	N	69	906	975
	%	100%	100%	100%

EP = Primary education, ES = Secondary education/high school, FP = Vocational education, N = None, X = I don't know, P = Postgraduate, U = University, N = sample

university studies and secondary/high school or elementary school, as shown in Table VI.

A similar issue was raised with regard to the mother's studies, a similar situation is observed as shown in Table VII. However, the difference in this case is not statistically significant.

This seems to indicate that university-educated parents show a preference for choosing private/concerted centres for their children's education.

The conclusions drawn from this comparison are presented in more detail in the discussion section.

TABLE VII
TYPOLOGY OF CENTRE. DISTINCTION BY PARENTAL EDUCATION

Q05.5. Father's studies:		Q05.1-R. Type of centre:		
		Private	Public	Total
EP	N	**3**	**76**	79
	%	**4.3%**	**8.4%**	8.1%
ES	N	**12**	**222**	234
	%	**17.4%**	**24.5%**	24.0%
FP	N	13	171	184
	%	18.8%	18.9%	18.9%
N	N	0	21	21
	%	0.0%	2.3%	2.2%
X	N	10	162	172
	%	14.5%	17.9%	17.6%
P	N	3	40	43
	%	4.3%	4.4%	4.4%
U	N	**28**	**214**	242
	%	**40.6%**	**23.6%**	24.8%
Total	N	69	906	975
	%	100%	100%	100%

EP = Primary education, ES = Secondary education/high school, FP = Vocational education, N = None, X = I don't know, P = Postgraduate, U = University, N = sample

V. PRACTICAL EXPERIENCE

To address the shortage of STEM professionals, a hands-on workshop was organised at Las Cocinas. The workshop included various activities that emphasised the Maker Education approach. This initiative responded to the need identified in the survey data analysed in this study and in the literature to intervene at an earlier stage, as by secondary school students have their ideas and thoughts (e.g. stereotypes) well established and it is difficult to change their minds. The workshop was conducted with a group of 3rd and 4th grade students who were not included in the survey analysed in this study because they are younger, and their participation in this workshop was a first pilot test. The workshop aimed to foster scientific-technological vocations among 3rd and 4th grade students through practical activities focused on the application of design principles, construction of prototypes, and use of various design and manufacturing tools, all of which were present in this space.

The workshop lasted approximately three hours and was structured into different parts, with the format based on a previous workshop held in this space, which is documented in the work of R. Araña [48]. The introductory section provided an overview of engineering and its relationship with STEM subjects. The aim was to encourage active participation from students to facilitate meaningful learning. Examples relevant to their environment were used to aid comprehension. The section also highlighted the significant role played by individuals, including women, in the field of engineering. Prominent female role models, both current and national, were presented to help students identify relatable figures.

Following this theoretical introduction, various manufacturing technologies were demonstrated, including additive manufacturing, laser cutting and engraving, and digitizing technology.

The activity of digitalization was highly interactive, enabling students to enjoy scanning their classmates or being scanned. The resulting scans could be exported to additive

Fig. 5. Experience in Maker Space with 3rd and 4th grade students. Working with laser cutting and engraving technology.and microscope analysis.

manufacturing technology, demonstrating the interaction and complementarity of the technologies. Two different additive manufacturing technologies were observed: filament extrusion and photopolymerization. The students were afforded the opportunity to observe the entirety of the production process, from the initial conceptualisation of the product to its subsequent manufacture, and to take away a bespoke item. With regard to the activities pertaining to laser cutting and engraving technology, the students were able to gain insight into the underlying physics principles, which were adapted to their level of understanding. They were also able to apply their knowledge in a practical manner by working with the machine technician to generate parts that could be transformed into tangible souvenirs. Furthermore, the workshop afforded students the chance to examine a variety of components in greater detail through the use of microscopes, as illustrated in Fig. 5. This comprehensive and technologically enriching approach was designed to stimulate meaningful learning and foster an interest in scientific and technological careers, positioning the workshop as an effective strategy for achieving this objective.

It is worth noting that this workshop was taught by students, graduates, and trainees of the ULPGC doctoral program, all of whom belong to the degree in Industrial Design and Product Development Engineering. This approach aimed to help students understand that the workshop instructors were closer in age to them, which could lead to better comprehension. This resulted in a great participation of the students.

At the conclusion of the experience, the participants were requested to provide their impressions of the experience. The majority of the students expressed high levels of satisfaction, particularly citing the notable presence of numerous female educators who facilitated the workshops. This demonstrates that, from an early age, students place a high value on having role models in their immediate vicinity.

To conclude the workshop, a series of exploratory questions were posed to ascertain the presence of impostor syndrome and the influence of female role models, as illustrated in the following section.

P1: Do you ever experienced a sense of undeserving, such that you felt you did not merit a favourable grade or an accolade you received?

P2: To what extent do you believe that your achievements have been the result of fortuitous circumstances, or of your own efforts?

P3: Do you ever consider that the male students in your class may possess greater proficiency in technology and mathematics related activities than you?

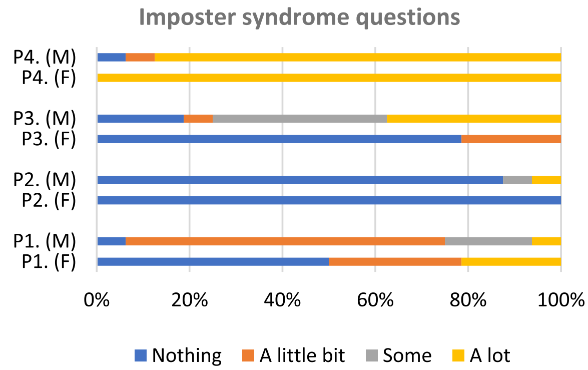

Fig. 6. Graph on the responses of young people in relation to the impostor syndrome.

- P4. Do you ever consider that the female students in your class may be less proficient than you in technology- and mathematics-related activities? (For males)

The findings of the study indicated that female students exhibited a proclivity for technological subjects and perceived themselves as highly proficient in this domain. However, their peers indicated that they perceived them to be less proficient than themselves in technology related activities, as illustrated in Figure 6.

This perception could have repercussions in future courses, potentially leading to female students rejecting the STEM field. The initial point emphasises the significance of recognising and tackling these challenges early on.

Conversely, in response to the question regarding role models, 93% of female students indicated a strong preference for female teachers in the STEM field, thereby underscoring the pivotal role of proximal role models.

This experience was highly beneficial as students gave feedback through multiple messages indicating a positive influence of these workshops in encouraging STEM vocations.

VI. Discussion

This section will analyze various factors that affect the lack of motivation of students, particularly females in STEAM disciplines, supporting those previously documented in the scientific literature.

Throughout this study, the perceptions and motivations of high school students in relation to STEM studies are examined, focusing on attitudes, motivations, role models, and participation in STEM-related extracurricular activities.

The discussion on beliefs, attitudes and motivations towards STEM studies highlights that girls often perceive more barriers than boys. These barriers include a lack of confidence in their abilities and limited information about job opportunities in these fields. Furthermore, it has been highlighted that girls are more motivated by contributing to the welfare of others and improving society, while boys exhibit greater motivation towards economic aspects and competition. These results are consistent with those of Merayo and Ayuso [43]. Therefore, it is necessary to address students' perceptions and motivations, particularly gender differences, to encourage greater participation of girls in STEM studies.

On the other hand, it is observed that female students identify fewer role models in STEM fields compared to their male counterparts. Furthermore, the only female figure recognized in STEM was Marie Curie, indicating a lack of diversity in female role models in these fields. These results highlight the significance of offering diverse and accessible role models to female students, in order to encourage their interest and participation in STEM studies. As noted by Szenkman and Lotitto, mentoring and early exposure of girls to role models have a significant impact on their confidence and personal and career decisions [39].

According to the research of Yoel and Dori [24], the influence of close role models is a crucial factor in students' future academic decisions [33]. This study supports the notion that the lack of encouragement from teachers or family members can hinder students' interest in technological disciplines, as expressed by both male and female students.

The research highlights the importance of role models in shaping academic aspirations. It emphasizes that the absence of support and guidance in the immediate environment can negatively impact students' inclination towards technological areas. This is reflected by authors such as Baltazar and Aguilar [34].

Therefore, it is important to intervene at the educational and family levels to establish an environment that fosters admiration and encouragement towards technological disciplines from an early age. This can play a fundamental role in shaping future academic choices, helping to close gender gaps and promoting more equitable participation in these areas.

In relation to participation in extracurricular STEM activities, it was found that the majority of surveyed students do not engage in such activities outside of the classroom, with girls participating less than boys. This highlights the need to provide opportunities for students, particularly girls, to participate in STEM activities outside of the classroom to encourage their interest and involvement in STEM studies. This can help to prevent the impostor phenomenon, which is more prevalent among female students [30].

Similarly, the workshop conducted with a limited sample of 30 elementary school students highlighted the importance of having a female teacher in scientific-technological subjects. This mentoring task positively influences the students' confidence and encourages a more proactive attitude However, it has been observed that students persist in the belief that girls are inferior in technical areas from an early age. This finding aligns with previous literature on the impostor syndrome in female students at more advanced stages, emphasising the need for early intervention, even before high school [32]. The survey results demonstrate that gender biases are already present during high school. However, it has been observed that girls at these ages do not adopt stereotypical beliefs. Therefore, further research should focus on maintaining and strengthening this motivation in the next educational stage.

Finally, regarding the objective of focusing on the experience of Maker Education, it has been observed that confidence, creativity, and interest in the field < of STEAM have developed while taking advantage of academic learning through teamwork, as explained by the author Maaia in his doctoral thesis [22].

VII. Conclusion

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

Additionally, almost half of the students surveyed reported a lack of support from their family members or teachers to pursue studies in STEM fields. This data is critical and requires further analysis and implementation of solutions. Role models have a significant impact on students' future academic decisions.

The significance of role models has become apparent for both genders, but particularly for female students. It is essential to have role models who are close to them, as they motivate and demonstrate that they possess the necessary attitudes and aptitudes, encouraging them to continue studying what they enjoy.

Similarly, research and pilot studies with primary school students have shown the importance of promoting STEM vocations from an early age. At the secondary school level, where gender bias is already prevalent, it may be challenging to alter ingrained perceptions, such as the impostor syndrome associated with the belief of lacking ability to pursue careers in this field.

Finally, after attending the workshops, a significant percentage of students displayed an increased interest in pursuing university studies and considering the possibility of pursuing STEM careers in the future. This was particularly evident among female students.

Nevertheless, the involvement of students in the workshop was constrained, thus it is recommended that additional workshops be conducted in the future with the objective of creating a substantial impact and promoting an expansion in STEM occupations.

For future research, it is proposed that a more exhaustive study be undertaken to contrast private and public schools in order to ascertain potential discrepancies in the educational experience that may contribute to the dearth of STEM vocations.

To conclude, based on the findings of the study, practical strategies are proposed with a focus on educational interventions that are applicable to different contexts. These strategies address both school and community settings and could serve as a reference for future policies and studies focusing on gender equality in STEM:

1. Integrate female STEM role models into the classroom by:
   - Inviting inspiring professionals: The presence of prominent women in STEM in school talks and activities provides girls with tangible models of success in these disciplines.
   - Gender-responsive curriculum: Incorporating historical and contemporary examples of women in STEM into academic content, helping to redefine notions of competence and career aspiration.
   - Recurrent workshops and seminars: Organising events with relevant figures in STEM can reinforce the perception of these disciplines as accessible and attractive to both genders.

2. Hands-on experience and early education through
   - Project-based learning programmes: Introducing interactive activities at early stages of education can encourage greater participation and enjoyment of STEM.
   - Equal access to robotics and coding workshops: Create opportunities for boys and girls to experiment and develop technical skills by working with technology and science centres to provide inclusive and affordable programmes.
   - Out-of-school experiences: Initiate outreach programmes, such as visits to science labs and museums, that are accessible to students from diverse socio-economic backgrounds.
3. Support and mentoring programmes. Ongoing mentoring in STEM is crucial to student retention and interest:
   - Targeted mentoring: Establish mentoring programmes that link students with STEM professionals, promoting ongoing support and the development of a network of contacts in the field.
   - Gender-sensitive teacher training: Train educators to raise awareness of the importance of equity in STEM and equip them with strategies to motivate and mentor all their students, regardless of gender.
   - Family empowerment: Provide workshops and resources for parents to help them encourage their daughters' interest in STEM at home.
4. Awareness and visibility campaigns: Creating outreach campaigns that break down gender stereotypes in STEM is critical to motivating girls:
   - Promoting opportunities for women in STEM: Develop campaigns that highlight the positive impact of STEM careers on society and inspire girls through testimonials of successful women.
   - Use social networking and media: Sharing success stories of women in STEM on accessible platforms helps counter gender stereotypes and makes visible the potential of women in these disciplines.
   - Inclusive science and technology fairs: Organise fairs where both girls and boys showcase innovative projects, highlighting female leadership and fostering a collaborative and equitable environment.

These recommendations not only help to reduce the gender gap in STEM, but also lay the groundwork for future research into the effective implementation of role models and the impact of interventions in different educational settings. By implementing these strategies, it is possible to promote a technologically advanced and inclusive society where access to STEM disciplines is not limited by gender stereotypes or barriers.

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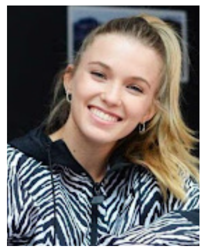

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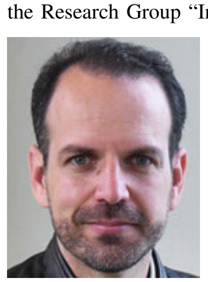

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