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# The lack of STEM vocations and gender gap in secondary education students

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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. Some of the multiple causes include cultural factors, gender stereotypes, and lack of female role models. Therefore, it is essential to promote gender equality and encourage inclusion and diversity in the educational environment as a key measure to reduce the gap. This is why in this study comprehensive research was carried out to analyse the factors that contribute to the gender gap in STEM careers. To this end, a survey was conducted of approximately 1,000 secondary education students from a range of centres in the Canary Islands. The survey yielded insights into the direct influence of close references on students and the lack of female role models. 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 to students that there are numerous role models nearby who can motivate and encourage them to explore and develop their interest in the field of science and technology. By providing said opportunities and role models, our aim is to build their 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, STEAM vocations, maker education, female role models, family influence**

## 1 Introduction

Today, women's equality in all spheres of society is positioned as one of the main objectives of organisations and governments. Some of the most important organisations seek to promote gender equality and women's empowerment through different initiatives to achieve the Sustainable Development Goals (SDGs) (UNESCO, 2023). Although much progress has been made in recent years, the situation may vary from country to country and from one sector of society to another. Especially in Science, Technology, Engineering and Mathematics (STEM) professions, female participation remains low (García-Holgado et al., 2019). This gap is particularly related to factors that represent barriers to achieving gender equity in STEM fields. These include lack of exposure to STEM career fields, the presence of gender stereotypes and biases, and the influence of parents and peers (Mau et al., 2020). Encouraging women to pursue careers in science requires an inclusive and gender-neutral educational and professional perspective. One effective way to do this is to include female references in curricula, so as to break down stereotypical images that limit women's choice of studies (Díaz, 2022).

The primary objective of this paper is to examine the gender gap in secondary and high school students in relation to vocational pursuits in STEM fields. The accumulating evidence at different educational levels indicates a dearth of interest in the scientific-technological field among both genders, with a more pronounced manifestation in the female gender. Secondly, the study aims to identify and analyse the factors that contribute to young people's rejection of these disciplines. The objective is to isolate some of the variables that contribute to this disaffection.

The 21st century has had a significant impact on lifestyles due to technological changes, which influence the transformation of young and adult society. In terms of education, these changes have generated the need to investigate new paradigms, where technologies present innovative challenges in teaching, such as the STEAM approach or methodology, which plays a crucial role in the environmental, economic and social transformations we are currently experiencing (Ortega-Rodríguez, 2022). This acronym is the evolution of STEM, where the A refers to the virtues of design and art in all their dimensions, such as critical and creative thinking (Castro-Campos, 2022). The globalised vision of STEAM implies that it provides transversal competences and soft skills from a contextual applicability (Ludeña, 2019).

This is because education today is confronted with the characteristics of an information society, which leads us to reflect on the role of education in the knowledge society and the type of individuals demanded by the 21st century society (Aguirre et al., 2019).

As education seeks new strategies to prepare students to become successful professionals in today's labour market, more attention is being paid to STEAM and related learning methods. In contrast to traditional teaching methods, the STEAM approach blurs the boundaries between disciplines to solve problems and promote higher levels of creativity and efficiency (Iroda, 2022). Since 2013, significant entities such as Fundación Telefónica have highlighted this issue in research involving 50,000 teachers from 14 different countries. In addition, the European Union has established guidelines as part of its Digital Education Action Plan (Torres, 2021).

According to predictions, the field of STEAM, in particular Engineering and Technologies such as the Internet of Things, Big Data and Artificial Intelligence, are bringing about a significant transformation in our society and in the labour market, digitising at a dizzying pace (Ayuso et al., 2022). This social transformation will require the education of students trained to learn and acquire 21st century skills, such as communication, critical thinking, creativity and collaboration, so that they can effectively integrate into the world of work and society (Education for Life and Work, 2012).

# 2 State of play of the gender gap in STEM fields

Recent years have seen a decline in student interest in STEM education despite the growing need for STEM professionals. Moreover, especially in the context of most engineering disciplines, there is a gender gap in these disciplines, where the number of women entering is very low (Peñalvo, 2023).

The gender gap in STEM studies is influenced by myths and misconceptions, as well as inadequate representations and other factors both internal and external to the individual, such as social and family context (Verdugo-Castro et al., 2020). This problem is reflected in the phenomenon known as the 'Leaky Pipeline', where women seem to lose interest in STEM studies at university as they get older (Goulden et al., 2011). Some of these aspects are briefly described below.

## 2.1 Cause of rejection

Due to its relevance, several studies have addressed the impostor phenomenon and the fear of failure in various settings, such as education and the work environment, analysing its influence in relation to gender and culture (Montes et al., 2021). The impostor phenomenon has been found to have a negative impact on students' self-efficacy, particularly for women, which may help explain why some of them avoid studying in STEM fields (Jöstl et al., 2012). Furthermore, several studies indicate that the perception of mathematics as a predominantly male discipline persists. This perception is not unique to the male perspective; even young women who opt for careers in STEM fields tend to perceive the subjects, with the exception of physics, as associated with the male gender, although this association is only slight (Makarova et al., 2019).

Further studies revealed that the impostor phenomenon affects self-efficacy in doctoral research, but the presence of female mentors and peers can help women persist in STEM (Tao and Gloria, 2019). Furthermore, it has been observed that women may experience the impostor phenomenon from an early age, but some develop strategies to overcome these feelings and continue in STEM (Blondeau and Awad, 2018).

## 2.2 Social cognitive theory

Social cognitive theory, developed by Bandura (1978), is a psychological approach that focuses on imitation and cognitive processing of information. This theory posits that learning occurs not only through direct experience but also through observation of others, particularly significant role models in the social environment (Eccles, 2011).

In the context of educational and occupational choices, social cognitive theory can be applied to understand how perceptions of gender roles, social expectations, and environmental influences shape individual educational decisions (Eccles, 2011).

This theory encompasses a number of key factors, including self-efficacy, outcome expectations, modelling and personal goals. These play a pivotal role in the academic and professional context, particularly in STEM fields (Lent et al., 2003). The concept of self-efficacy, first introduced by Bandura and subsequently applied to the field of career development by Hackett and Betz in 1981, has gained considerable prominence in the literature on professional and academic behaviour over the past two decades (Hackett and Betz, 1981). According to these authors, this construct, which refers to people's beliefs about their ability to perform certain actions, is crucial for understanding career development. In particular, the importance of self-efficacy is highlighted in the case of women, who tend to avoid male-dominated careers. In the field of STEM, several studies, such as those by Nauta et al. (1998), have demonstrated that self-efficacy exerts a significant influence on students' interests, academic performance, persistence and career aspirations. Accordingly, as Lent notes, self-confidence in one's abilities is associated with enhanced academic performance, perseverance in challenging academic pursuits, and a greater propensity to pursue careers in STEM fields (Lent et al., 2003).

Other elements, although less studied, play a crucial role in academic and professional development in STEM (Lent et al., 2003). As Eccles notes, modelling is a learning process whereby individuals observe and emulate the behaviour of others, which can significantly influence the acquisition of new skills and behaviours (Eccles, 2011). Outcome expectations, which are beliefs about the results that can be obtained by performing certain actions, impact motivation and decision-making in STEM (Lent et al., 2003). The conviction that positive outcomes are attainable exerts a profound influence on dedication and effort in these domains. Finally, it is important to note that setting specific and challenging personal goals in STEM is critical for academic and career motivation and achievement, as reflected by Bandura (1986). Clearly defined and meaningful objectives facilitate behaviour and assist in maintaining persistence in attaining objectives in these demanding fields (Lent et al., 2003).

In conclusion, self-efficacy, outcome expectations and personal goals are pivotal elements in academic and professional success in STEM. These psychological factors exert a significant influence on motivation, decision-making and perseverance in areas that require advanced technical and cognitive skills. It is therefore essential to understand and strengthen these factors if we are to foster interest and performance in STEM disciplines.

## 2.3 Female role models

One of the causes of female students' disinterest in STEM subjects is gender stereotypes. The way to combat these pervasive beliefs is by presenting female role models in STEM-related areas in the classroom. According to several studies, female students have better self-esteem when they have female role models. Also, providing female role models makes girls more curious and enhances the skills they actually have to pursue STEM careers in the future (Reinking and Martin, 2018). Insecurity is an obstacle for adolescent girls, so it is essential to make STEM careers understandable and highlight their impact on humanity and the social nature of technology to motivate them to opt for these careers (Riesco, 2022).

It is also important to note that mentoring programmes and early exposure of girls to role models have a significant impact on their confidence and the choices they make in their personal and professional development (Szenkman and Lotitto, 2020).

## 2.4 Influence of the immediate environment

To understand the lack of STEM vocations, the literature suggests that students' motivation may be influenced by several factors. One relevant element is the impact of their environment, such as family support, the presence of STEM role models in the family or the involvement of parents and teachers in motivating them towards STEM disciplines (Rocker Yoel and Dori, 2022).

The influence of good teachers and close family has been identified as the most significant influence on students' choice of STEM careers. In particular, women who choose to study STEM careers have been found to have been significantly influenced in their vocational choice by their mothers and some teachers (Baltazar and Aguilar, 2016). Similarly, research by Palmer et al. (2017), indicates that students whose parents work in STEM fields are more likely to choose STEM fields and teachers may influence STEM career decisions (Menacho et al., 2021).

Indeed, research such as that conducted by authors Hoferichter and Raufelder has shown that there is a disparity between girls and boys in terms of perceived parental pressure or support related to their academic performance. In the case of students, their performance is influenced by the peer group rather than by parental influence. On the other hand, in the case of female students, it has been observed that the support provided by both mother and father during the eighth grade correlates with better performance in subjects such as mathematics and biology (Hoferichter and Raufelder, 2019).

Another aspect of significance is highlighted by study of Lam (2023), which posits that parental attitudes and behaviours towards gender stereotypes may influence children's early comprehension and reasoning about toys. This suggests that parents may indirectly influence their children's toy preferences through their own beliefs and expectations.

# 3 Materials and methods

The study presented here had its antecedent in another previous research related to the project 'Get closer to engineering' from which it was possible to obtain some initial data that showed the present crisis in STEM disciplines and which gave rise to further study in this field. In this research, a survey with a Pre-Test and Post-Test design was used as an instrument. First the Pre-Test was carried out to see the starting point of the students and after that the project was carried out where the students did various activities to learn first hand about engineering and what is related to it. At the end of the experience, the questionnaire was repeated (Post-Test) to see the impact the project had on the students and it was here where interesting data was obtained.

Thanks to this design, it was possible to observe how the percentages in some of the questions tended to be more negative, due to first-hand knowledge of the relative difficulty involved in engineering degrees and, therefore, they responded with greater criteria reflecting that they did not consider themselves to have the skills to be able to successfully undertake this type of degree. Despite these results, on the other hand, the experience resulted in an increase in both genders, mainly in the case of female students, in wanting to pursue university degrees and specifically engineering degrees. 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, in order for them to understand that they have the same capabilities and potential as their male peers.

With this in mind, therefore, the study that follows takes a more detailed look at the different aspects of the students' immediate environment, in order to see which factors have the greatest impact on them and on which measures or solutions could be taken.

## 3.1 Data analysis

The statistical analysis presented in this article was conducted using Jamovi (R Core Team, 2022; Jamovi, 2019), with a confidence level of 95% employed in all cases. The Shapiro–Wilk tests indicate that the data collected exhibit a non-normal distribution, and thus require the use of non-parametric statistical tests.

The descriptive phase is primarily based on an exploratory analysis. The objective of the descriptive statistics is to analyse the main results obtained through the questionnaire, quantifying the response frequencies.

Conversely, in the context of relationships between variables, chi-square tests of association are employed to ascertain whether there is a statistically significant association due to the discrete nature of the variables.

## 3.2 Participants

The group of students selected for this study has been carefully chosen to adequately represent the diversity of the student population in the Canary Islands, Spain. The group comprises 975 students, ranging from the second year of Compulsory Secondary Education (ESO) to the second year of Baccalaureate, and hailing from educational institutions situated on various islands within the Canary Islands archipelago.

The selection of this group is based on the main objective of the study, which is to obtain an overview of vocations in STEAM areas (science, technology, engineering, art and mathematics) in the Canary Islands and to assess possible gender gaps associated with these areas. It is therefore of the utmost importance to ensure that the sample is representative of the geographical and demographic diversity of the student population in the archipelago.

To obtain this sample, contact was made with a variety of educational institutions in the different islands of the Canary Islands. This was achieved through both institutional mailings and direct contact with the schools. A particular focus was placed on including schools situated in different geographical areas of the islands and on representing both capital and non-capital islands. This approach ensures the representativeness and validity of the study's results, as it captures the diverse realities and educational contexts present in the Canary Islands.

It is also necessary to analyse the minimum representative sample, which is calculated using Cochran's (1963) equation with finite population correction (Figure 1). This equation describes the sample size ($n$) given a target confidence level, a margin of error ($\varepsilon$), a population proportion (p) and a population size ($N$).

In this case, during the academic year 2022/2023, for the courses mentioned there was a population of 65,000 people (de Canarias, 2022). Taking into account a 95% confidence value (score of 1.96), a margin of error of 5% and an assumed population proportion of 50%, the minimum sample needed to be representative would be 382 participants. As the questionnaire developed for this study was completed by a sample of 975 individuals, the minimum required (382) for a confidence level of 95% is exceeded by 593.

The sample of respondents reflected a fairly balanced gender composition, with 52.4% female students and 47.6% male students, distributed proportionally by year, as shown in Figure 2. These data are consistent with the statistics of the Spanish university system, where the number of female students entering university exceeds the number of male students, and where it can be seen that the gender ratio is more even in the first years of secondary school, but leans towards the female gender in the higher years (Ministerio de Universidades, 2022).

## 3.3 Instrument

The instrument used is the survey, a technique that is widely used as a research procedure because it allows data to be obtained and processed quickly and efficiently (Casas Anguita et al., 2003). The survey used is the 'Survey on the perception of barriers and supports in the choice of STEM studies addressed to secondary school students' by Álvarez and Lanchares (2023).

This questionnaire forms part of a research project which aims to analyse the perceptions of secondary school students with regard to science and technology careers and disciplines. The primary objective of this study is to identify the barriers and supports that influence the decision to pursue STEM degrees. Additionally, this study aims to analyse how these influences differ according to variables such as gender (Álvarez and Lanchares, 2023). The design of the questionnaire

$$n = \frac{\frac{Z^2 \cdot p(1-p)}{\varepsilon^2}}{1 + \frac{z^2 p(1-p)}{\varepsilon^2 N}}$$

FIGURE 1
Cochran's equation. Taken from Rocker Yoel and Dori (2022).

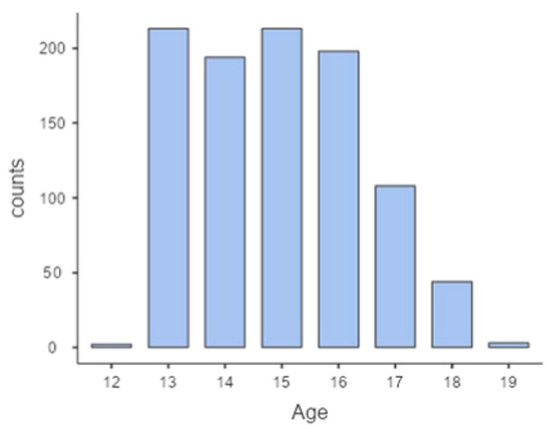



FIGURE 2
Bar chart of the distribution of pupils according to age.

was informed by a systematic review of the scientific literature related to the perception of STEM disciplines in young people (Palmer et al., 2017; Vennix et al., 2018; Fouad et al., 2010; Dasgupta and Stout, 2014; Salmi et al., 2016; Molina-Gaudo et al., 2010; Mainhard et al., 2018; Henriksen et al., 2015). This review enabled the items to be written in a more precise and informed way.

Once the questions of the questionnaire had been formulated, they were validated through the opinion of experts, namely three specialists in education and/or gender, who assessed the relevance and coherence of the questions. This feedback was of great importance in the finalisation of the questionnaire. Once the questionnaire had been administered, its reliability was assessed using the Cronbach's alpha coefficient, a widely recognised method for determining the internal consistency of a questionnaire (Amirrudin et al., 2021; Cortina, 1993). Cronbach's alpha results are considered satisfactory if the value obtained is greater than 0.6 (Cicchetti and Sparrow, 1981). In the case of the questionnaire administered to students, which covered all the variables considered, a value of 0.714 was obtained, indicating a satisfactory reliability of the instrument used.

To further substantiate the reliability of the instrument, it is noteworthy that this questionnaire has been employed in other studies (Ayuso et al., 2022; Merayo and Ayuso, 2022). The questions are distributed as follows, as shown in Table 1.

The questions are distributed as follows:

- eight dichotomous questions (yes or no);
- 13 questions to select one or more answers;
- nine questions with a Likert scale from 1 to 10 (1 being 'very little' and 10 being 'very much') and others with a scale of 5 (1 being 'strongly disagree' and 5 being 'strongly agree');
- seven open-ended short-answer questions; and
- six open-ended supporting questions:

  o Why do you think there are boys' and girls' toys or why not?
  o What would you like to do when you grow up?
  o Why do you think careers in Technology or Science are more for boys, girls or both?
  o What qualities do you think you need to have to study STEM disciplines?
  o Why do you find people who are professionally involved in Science, Technology or Engineering attractive, appealing or curious?
  o Name a famous or well-known role model in the STEM field.

In turn, the 45 questions are divided into five dimensions. The first one deals with socio-demographic aspects for comparison with the rest of the dimensions; the second one deals with students' tastes; the third one studies what kind of support students receive regarding the STEM field; the fourth one analyses students' opinion about this field; and the fifth dimension explores the references, both close and famous, that inspire students to follow more technical academic branches. In the first dimension, five additional questions necessary for the study were added separately (Q05.1; Q05.2, Q05.3, Q05.4, and Q05.5), which allowed to identify the type of school and parents' educational levels and ages.

Similarly, for the section related to the influences that students receive from their environment with regard to their choice in this branch, the Martín Carrasquilla scale was used (Martín, 2020), with six questions with a Likert-type scale from 1 to 5 (1 being 'totally disagree' and 5 'totally agree').

It is important to note that the results obtained have been subjected to statistical analysis using Jamovi software, with a confidence level of 95% in all cases.

## 4 Results

The results of this study are presented below. Initially, responses from secondary school students who did not take the questionnaire seriously were excluded. Subsequently, a comprehensive analysis of the five dimensions described in the previous section was conducted. The most salient aspects of each dimension, as well as the relationships observed between them, are presented below in a brief overview.

### 4.1 Dimension I: socio-demographic aspect

This dimension presents the socio-demographic aspects of the sample, focusing on the representation of the different educational levels and the type of educational centre to which the students belong, as well as the educational level of the respondents' parents.

It is important to note that an adequate representation of the different educational levels has been obtained. The second ESO level is the most numerous, comprising 39.1% of the respondents. The next largest group is that of 4th ESO students, with a percentage of 28.5%. This is followed by third ESO, first Baccalaureate and second Baccalaureate students, each with a percentage above 10%. These figures are illustrated in Figure 3. It also illustrates that the overwhelming majority of students (90.9%) attend public schools. The proportion of students attending private grant-aided schools is only 8.7% of the total sample. Furthermore, the map illustrates the concentration of these schools in the capital area.

This dimension also examines the educational attainment of the mothers (Q05.4) and fathers (Q05.5) of the students, as illustrated in Figure 4. Conversely, it is evident that a greater proportion of mothers have attained university and postgraduate qualifications compared to fathers. However, with regard to secondary or baccalaureate studies, as well as vocational training, both parents exhibit comparable percentages.

### 4.2 Dimension II: tastes

The selection of toys during childhood can provide valuable insights into the development and perpetuation of gender stereotypes within society. Toys serve not only a utilitarian function, but also play a pivotal role in the development of cognitive, social, and emotional skills. Toys are frequently imbued with gender connotations, which can influence children's preferences and choices from an early age. We could therefore ask the following questions: Are there significant differences in the types of toys preferred by boys and girls during childhood; how does gender influence the perception of the existence of specific toys for boys and girls?; How does gender influence the perception of the existence of specific toys for boys and girls? A

TABLE 1 Questionnaire.

| Socio-demographic questions | |
|---|---|
| **Questions** | **Answers** |
| Q01-R. Gender? | Female/Male/Other |
| Q02-R. Age? | |
| Q03-R. Course? | 2nd ESO/3rd ESO/4th ESO/1st Bachiller/2nd Bachiller |
| Q04. Institute | |
| Q05-R. Locality and/or Province of the institute | |
| Q05.1-R. Type of institute | Public/Private/Private subsidised private |
| Q05.2-R. Age of your mother | |
| Q05.3-R. Age of your father | |
| Q05.4-R. Education completed by your mother | None/Primary education/Secondary education/High school/Vocational training/University/Postgraduate/Do not know |
| Q05.5-R. Education completed by your father | None/Primary studies/Secondary studies/Baccalaureate/Vocational training/University/Postgraduate/I do not know |
| **Questions related to tastes/hobbies and personality** | |
| **Questions** | **Answers** |
| Q08-R. During my childhood, I had games and toys related to construction, legos, puzzles, cars, etc. | Yes/No |
| Q09-R. What kind of toys did you play with as a child? | Dolls/dolls/Scalextric/Legos/constructions/Puzzles/Cars/motorbikes/airplanes/trucks/Skateboards/skateboard/bike/Board games/Playmobil/Consoles/Balls/Other |
| Q10-R. Do you think there are boys' toys and girls' toys? | Yes/No |
| Q11-R. Why? | |
| Q12-R. What do you like to spend your leisure time doing? | Listening to music/Being with friends/Social networking/Playing sports/Playing video games/Reading/Other |
| **Questions related to STEM support and extra-curricular activities** | |
| **Questions** | **Answers** |
| Q13-R. My mother/father or guardian has taken me or has taken me to do activities related to Technology/Math/Science/Computer Science. | Likert scale |
| Q14-R. My teacher(s) encourage me to do activities related to Technology/Math/Science/Computer Science | Likert scale |
| Q15-R. I now frequently participate in activities outside of school hours related to Mathematics, Technology, Science, Computer Science. | Likert scale |
| Q16-R. I am currently encouraged by my parents/guardians to participate in activities outside of school hours related to Mathematics, Technology, Science, Computer Science. | Likert scale |
| Q17-R. Currently, my teachers encourage me to participate in activities outside of school hours related to Mathematics, Technology, Science, Computer Science. | Likert scale |
| **Questions related to perception and opinion on STEM studies** | |
| **Questions** | **Answers** |
| Q18-R. Do you most like subjects related to: | writing, language, reading, literature, history, history, music, art…/mathematics, physics, chemistry, biology, technology… |
| Q19-R. What would you like to do when you grow up? | |
| Q20-R. Do you want to continue studying when you finish ESO/Bachillerato? | Yes/No |
| Q21-R. If you answered yes, would you like to study? | A university degree/a vocational training course |
| Q22-R. In both cases above, would you like it to be linked to Technology or Science? | Yes/No |
| Q23-R. Do you think that careers in Technology or Science are more…? | Of girls/of boys/of both |
| Q24-R. Why? | |

*(Continued)*

TABLE 1 (Continued)

| Socio-demographic questions | |
|---|---|
| **Questions** | **Answers** |
| Q25-R. Do you think you have to have any special qualities to study these degrees or studies? | Yes/No |
| Q26-R. Which one(s)? | |
| Q27-R. Do you find people who are professionally engaged in Science, Technology or Engineering attractive, attractive or curious? | Yes/No |
| Q28-R. Why? | |
| Q29-R. Of the following questions, which do you consider most important for not choosing a career in Science, Technology or Engineering? | My personal ability/I do not like it/I do not understand what they do/I think people who study this degree are freaks/I do not think they contribute something to society/Other |
| Q30-R. Which of the following questions do you consider most relevant for choosing a career in Science, Technology or Engineering? | Social recognition (prestige)/Earning a lot of money/Helping others/Improving society/Teamwork/Employment opportunities/Personal improvement/Other |
| **Related questions about STEM references** | |
| **Questions** | **Answers** |
| Q31-R. Do you know any 'man or woman' in your close environment who works in any field of Science, Technology or Engineering? | Father/guardian/Mother/guardian/Uncles/Aunts/Uncles/Cousins/Cousins/Other relatives/Friends or acquaintances/Teachers/I do not know anyone in my environment |
| Q31.1-R. My family encourages me to study science in the future. | Likert scale |
| Q31.2-R. My family shares my interest in Science. | Likert scale |
| Q31.3-R. My classmates encourage me with Science. | Likert scale |
| Q31.4-R. My peers think Science is not important. | Likert scale |
| Q31.5-R. Peers who are important to me would think it is good for me to study Science in the future. | Likert scale |
| Q31.6-R. I think my classmates would like me to study Science in the future. | Likert scale |
| Q32-R. Name a famous/known 'male or female' reference in any field of technology, science or engineering. | |

comprehensive examination of the preferences and perceptions of gender with regard to toys among the surveyed students is presented below.

In this second dimension, which deals with tastes, generically all the students reported having had toys related to construction, cars, etc. However, if we analyse what type of toys each of them used as children, in the case of female students, dolls, skateboards and puzzles are the most popular, while in the case of male students, balls, cars/motorbikes and Legos are the most popular. Therefore, a confidence interval has been defined for the difference in proportions, analysing whether students consider that there are boys' and girls' toys (see Table 2). The result obtained shows a statistically significant difference in proportions, ranging between 20 and 30% (in the sample, 32.75% of boys consider that there are boys' and girls' toys compared to 8.02% of girls), so there is statistical significance.

As for the use of free time, although both genders agree that they prefer listening to music and meeting friends, in the case of pupils, they have a much higher percentage when it comes to playing sport and video games.

## 4.3 Dimension III: STEM support

It is becoming increasingly clear that education in the STEM field is crucial for the development of skills that are in high demand in the world of work. Nevertheless, the extent to which students engage in STEM-related activities is largely contingent upon the level of support and motivation they receive from their parents and teachers. Such support can have a significant impact on students' interest and engagement in these areas of study. It is therefore crucial to ask: Are there differences in the perception of support received between students of different genders?; What barriers do students perceive that prevent them from actively participating in STEM activities?

The third dimension analyses the support students receive in the STEM field. Here it was observed that around 70% of them indicated that their teachers did encourage them to take part in activities related to this field.

In addition, students' participation in STEM extracurricular activities, family support for such activities and support received from teachers were also analysed. In this case, practically 50% of the sample in both genders is placed between values 1 and 4 on a scale of 1 to 10 ('1' being very little and '10' a lot), so they neither participate in this type of activities voluntarily, nor do they consider that their closest referents such as family and teachers encourage them to do so.

## 4.4 Dimension IV: STEM opinion

The academic and professional careers chosen by students are profoundly influenced by their interests, perceptions and the support

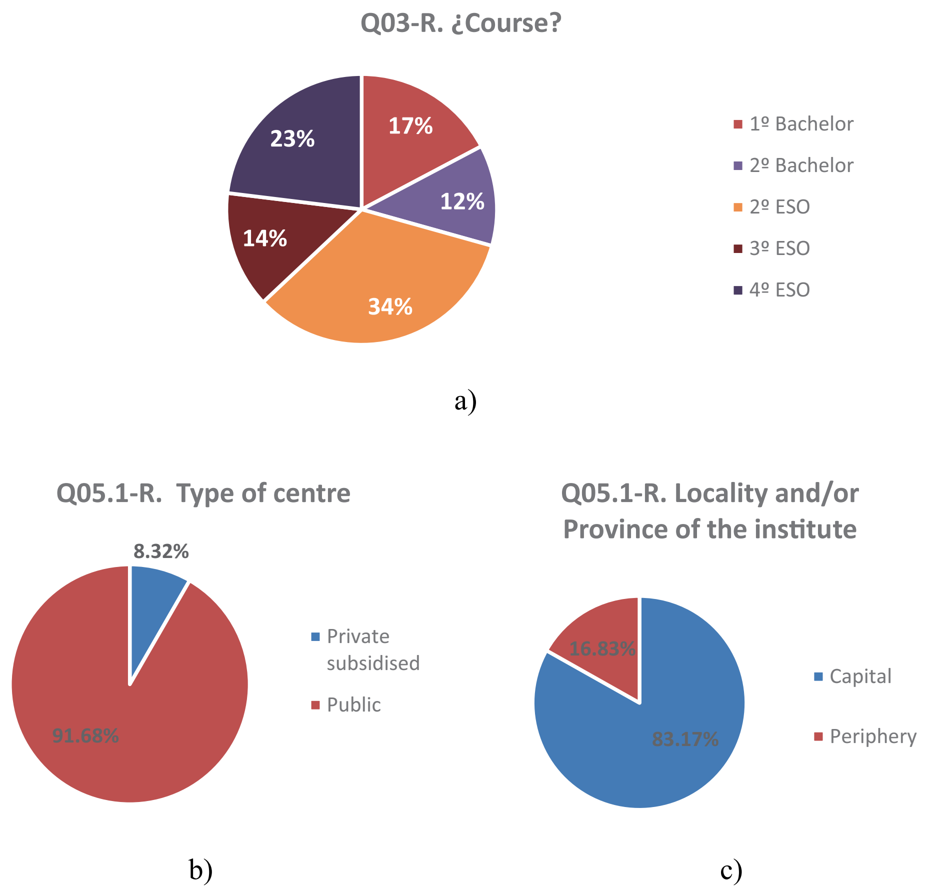



FIGURE 3
Chart on **(a)** educational level of participating students; **(b)** type of centres and **(c)** location of centres.

they receive from their environment. In particular, the STEM field faces challenges in terms of attracting and retaining students of both genders, especially women, due to the gender stereotypes and perceptions that still persist. Knowing this, the questions that arise are: Are there gender differences in academic preferences towards sociolinguistic vs. STEM disciplines?; How do perceptions of personal ability and social value affect the choice of STEM careers among students of both genders; what factors do students consider most relevant when choosing a STEM career and how do these factors vary between genders?

This dimension shows the clear gender bias, with 53% of female students preferring sociolinguistic subjects, compared to 35% of male students. However, it is the girls who do have a clear decision to continue their academic studies, with 97% compared to 88% of their male counterparts, and with the same difference in terms of wanting to study a university degree as opposed to a vocational training course. However, when asked whether they want these studies to be related to the STEM field, the percentage is reversed, with 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.

Similarly, we wanted to analyse why they were not interested in this type of discipline (Figure 5a), especially in the case of female students. The results seem to indicate that, in both genders, the two issues that most influence the decision not to opt for this type of degree are personal ability and lack of interest, the percentage being slightly higher in the case of female students. Another aspect that also has some influence, although to a lesser extent, is the perception that these degrees do not add value to society. This concept possibly stems from the students' lack of knowledge in this field.

On the other hand, the aspects that respondents considered most relevant for choosing a STEM career included the possibility of earning a high income, contributing to the betterment of society, employment opportunities and the ability to help others (Figure 5b). On the other hand, the prestige factor was rated less highly by both genders.

## 4.5 Dimension V: STEM references

The role of role models in influencing students' academic and career aspirations is particularly significant in highly specialised fields. The presence of role models can significantly influence young people's decision to pursue a career in these fields, providing them with inspiration and a clear vision of what they can achieve. Some research questions that have been raised in this dimension are: How do peers influence students' decision to pursue careers in the STEM field; Do teachers play an important role as role models in the choice of STEM careers for students of both genders; Is there knowledge of role models, both historical and current, especially female ones; Is there knowledge of role models, both historical and current, especially female ones?

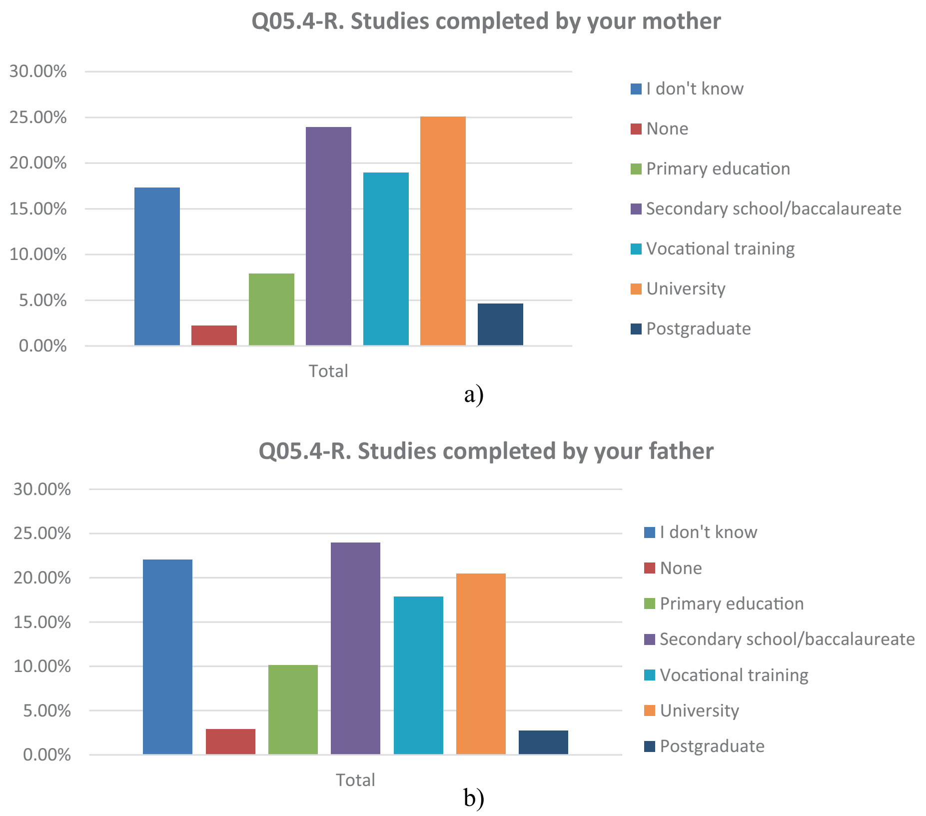



FIGURE 4
**(a)** Chart on educational level of respondents' mothers; **(b)** Chart on educational level of respondents' fathers.

TABLE 2 **Representation of students' consideration of having toys by gender.**

| Gender in STEM toys | | | |
|---|---|---|---|
| Gender | No | Yes | Total |
| Female | 470 | 41 | 511 |
| Male | 312 | 152 | 464 |
| Total | 782 | 193 | 975 |

The last dimension analyses the students' references. It shows that both male and female students do not feel that their peers encourage them to study science; moreover, female students highlight that their closest friends do not think it is good for them to study science.

With regard to their closest references working in the STEM field, in the case of female students, the references are teachers, with 47%, followed by friends and other family members, with 24 and 22%, respectively. For their part, male students also have similar points of reference, although in a smaller proportion in the case of teachers. In addition, it is observed that, for them, parents and uncles and aunts can also be close referents, as shown in Figure 6.

Likewise, in both cases, the students show that they have no knowledge of famous current references, much less female ones, indicating only old references such as Albert Einstein, Marie Curie or Tesla.

## 4.6 Relationship between dimensions

As mentioned above, the first of the blocks was used to make several comparisons.

The choice of subject and the level of support provided by teachers are significant factors influencing students' academic orientation towards specific fields such as STEM. In light of these considerations, some of the questions that have been posed are as follows: How does the type of school influence the subject preferences of students of both genders?; Are there significant differences in the support received from teachers in public vs. charter schools in relation to the study of STEM disciplines?

In order to answer the initial question, it is necessary to consider the data presented in Figure 7, it was observed that, in the case of boys, both schools showed a preference for technological subjects, especially in state schools, where this preference increased by 13%, reaching 69%. On the other hand, girls in grant-aided schools show a 60% preference for sociolinguistic subjects, while in state schools the sample is evenly divided between both types of subjects.

Within this classification of schools, in answer to the second question, an observation of the degree of teacher involvement was carried out, as the lack of teacher stability in the classroom is often criticised. In private grant-aided schools, similar data were found for both genders, with 65% of students indicating that they received support from teachers in the study of STEM fields. In public schools, as shown in Figure 8, a similar situation is observed, with 70% of female students reporting that they receive such support from teachers.


FIGURE 5
**(a)** Charts on determinants of STEM-related degree choice; **(b)** Charts on determinants for not choosing a STEM related degree. F, Female; M, Male.

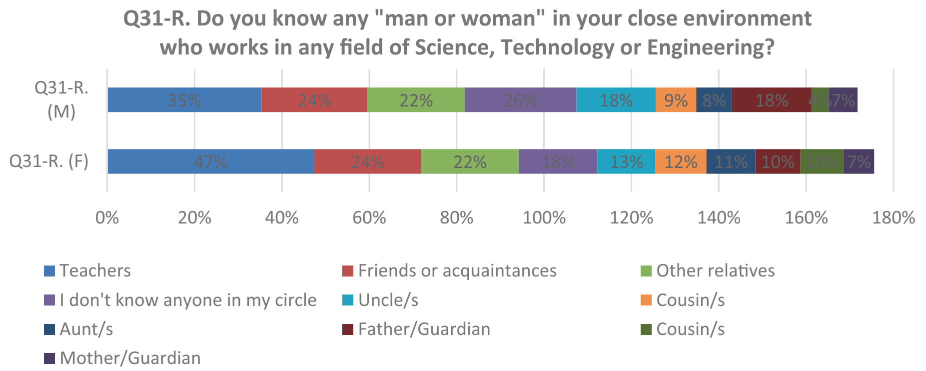



FIGURE 6
Chart on people close to you who are related to STEM field. F, Female; M, Male.

Therefore, it can be concluded that, in the Canary Islands, regardless of the type of educational centre, teachers play a mentoring role in the field of technical disciplines, encouraging their students to study them, although one third of the students indicate that they do not perceive this.

In addition, an analysis of the geographical location of the schools surveyed was carried out, and it was found that 83.2% of them are located in urban areas or capital cities, while 16.8% are in peripheral areas.

This analysis was carried out with the aim of examining whether the location of the school has any influence on aspects related to the

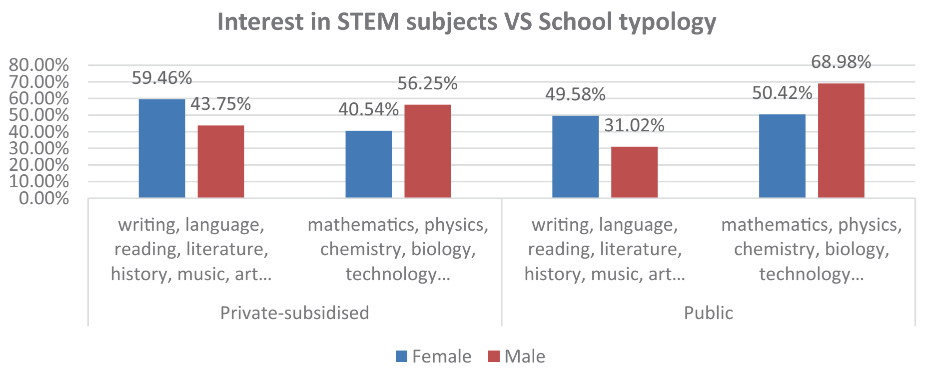



FIGURE 7
Graph showing the subjects they like the most according to the type of school they attend.

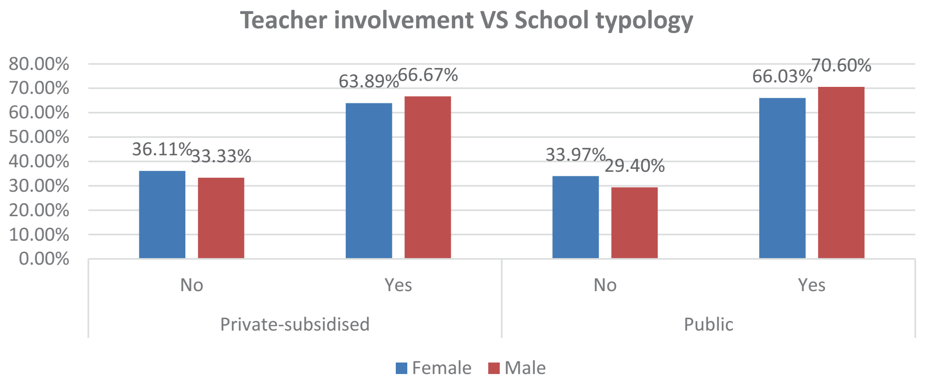



FIGURE 8
Graph comparing teaching staff from different types of schools.

students' academic future. For example, the relationship between school location and students' desire to continue their studies was analysed, as well as the type of study they would choose in this decision, as shown in Figure 9.

In the case of boys, it is observed that those who indicated that they do not wish to continue studying opted mainly for vocational training cycles, especially in peripheral areas, representing the total percentage. This suggests that their objective is to pursue these studies in order to enter directly into the labour market. On the other hand, those who expressed a desire to study, both in urban and peripheral areas, have in mind mainly university studies. On the other hand, in the case of girls who stated that they do not want to continue studying, only those in urban areas indicated that 67% would opt for a vocational training cycle and the remaining 33% would choose a university degree, which may reflect a lack of clear decision about their future, because like the students, these are confusing results since they have chosen type of degree even though they indicated that they do not want to continue studying. On the other hand, the girls who stated that they would continue studying, 70% of those in urban areas expressed their intention to pursue a university degree, while in peripheral areas this percentage increased to 75%. In this case, girls studying in peripheral areas reflect their determination to continue studying, in contrast to girls in urban areas.

Students' choices of future degrees and their relationship to STEM is a key area of study for understanding gender differences in academic and career aspirations. We therefore wanted to ask the following question How do preferences for STEM studies vary by gender between vocational and university students? Figure 10 provides an answer to this question and shows relevant results, as there is a notable difference between the genders. In the case of students who wish to pursue a vocational training cycle, 68% of female students do not want it to be related to STEM, while 58% of male students do seek this connection. As for university degrees, something similar occurs, where 71% of the students want them to be related to STEM, while this percentage decreases to 56% in the case of female students. This shows, on the one hand, that the percentage of STEM-related studies is higher in both cases when it comes to university studies, and, on the other hand, that female students show a lower predisposition to study scientific-technological degrees.

Conversely, a further investigation was therefore conducted to ascertain the relationship between parents' level of education (Table 3) and students' desire to pursue STEM-related studies. The following question was posed: This study sought to determine the influence of parents' level of education on their children's choice of STEM-related studies? It is observed globally that the study of STEM in relation to

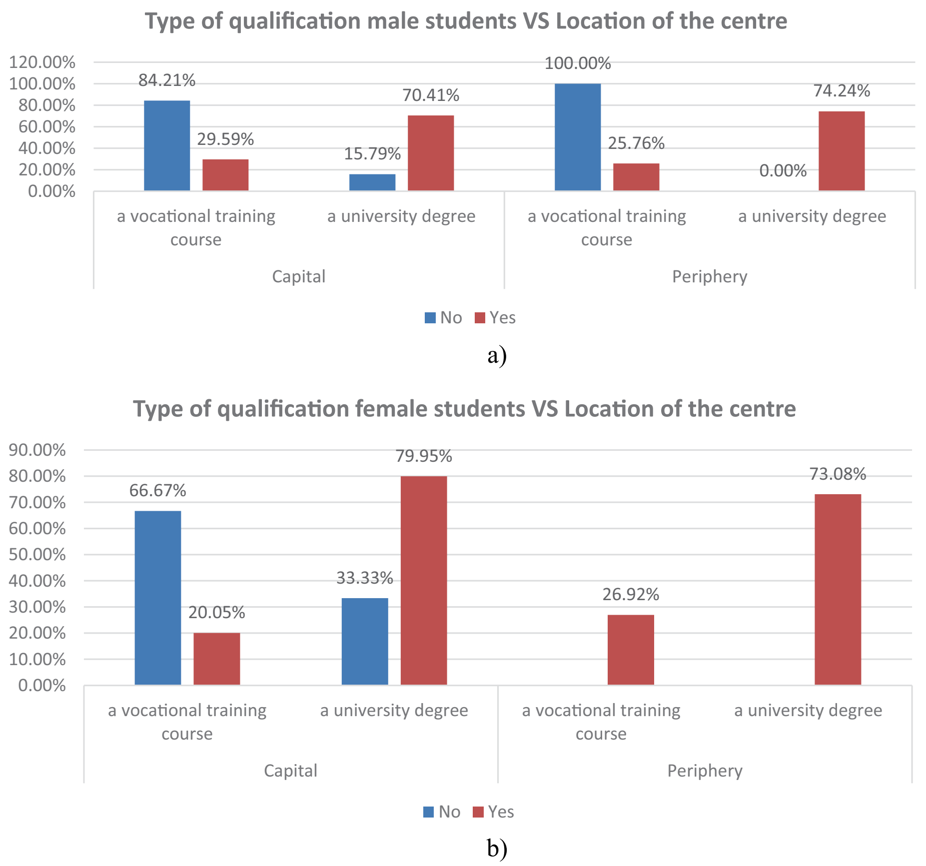



FIGURE 9
**(a)** Graph showing male students' choice of studies according to the location of the institution; **(b)** Graph showing female students' choice of studies according to the location of the institution.

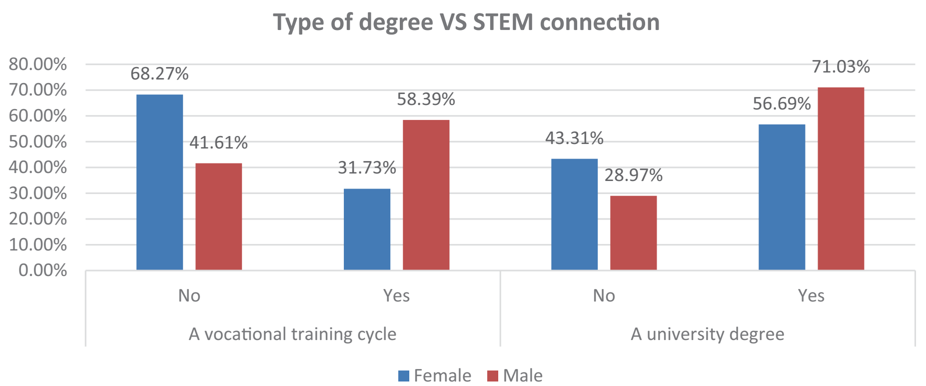


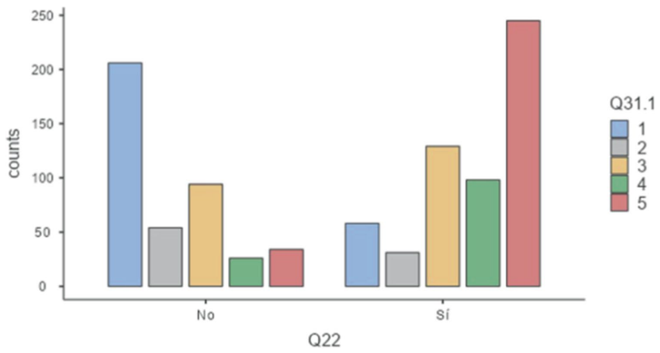

FIGURE 10
Graph relating degree type to STEM field.

the mother's education (Q5.4) influences the yes in a general way. Looking at it particularly, it is seen that the multiplier factor of the percentage is higher when the studies are university (almost double) or graduate (almost triple). The situation is similar in the case of the father's studies (Q5.5). The percentage multiplier factor is higher when the studies are undergraduate (almost double) or graduate (almost triple).

A further question was posed: how does the perception of parental support influence students' decision to pursue a career in STEM? This was investigated by examining the level of support students received from their parents to engage in STEM activities (Q31.1) on a Likert 5 scale (1 being 'totally disagree' and 5 'totally agree'), and to see how this could influence their future decision of whether or not to pursue STEM studies. What is observed in this

TABLE 3 Graph comparing parents' qualifications with students' STEM involvement.

| Q05.4/Q05.5 | Q22 | Frequencies | | % del Total | | % Accumulated | |
|---|---|---|---|---|---|---|---|
| | | Mother | Father | Mother | Father | Mother | Father |
| Primary education | No | 34 | 50 | 3.5% | 5.1% | 3.5% | 5.1% |
| | Yes | 45 | 50 | 4.6% | 5.1% | 8.1% | 10.3% |
| Secondary education | No | 107 | 105 | 11.0% | 10.8% | 19.1% | 21.0% |
| | Yes | 127 | 132 | 13.0% | 13.5% | 32.1% | 34.6% |
| Vocational training | No | 78 | 74 | 8.0% | 7.6% | 40.1% | 42.2% |
| | Yes | 106 | 96 | 10.9% | 9.8% | 51.0% | 52.0% |
| None | No | 9 | 9 | 0.9% | 0.9% | 51.9% | 52.9% |
| | Yes | 12 | 17 | 1.2% | 1.7% | 53.1% | 54.7% |
| I do not know | No | 80 | 99 | 8.2% | 10.2% | 61.3% | 64.8% |
| | Yes | 92 | 118 | 9.4% | 12.1% | 70.8% | 76.9% |
| Postgraduate studies | No | 13 | 7 | 1.3% | 0.7% | 72.1% | 77.6% |
| | Yes | 30 | 19 | 3.1% | 1.9% | 75.2% | 79.6% |
| University | No | 93 | 70 | 9.5% | 7.2% | 84.7% | 86.8% |
| | Yes | 149 | 129 | 15.3% | 13.2% | 100.0% | 100.0% |




| Descriptives | | |
|---|---|---|
| | Q22 | Q31.1 |
| N | No | 414.00 |
| | Yes | 561.00 |
| Mean | No | 2.10 |
| | Yes | 3.79 |
| Median | No | 2 |
| | Yes | 4 |
| Standard deviation | No | 1.31 |
| | Yes | 1.33 |

FIGURE 11
Graph relating the support of family members with respect to wanting to pursue studies in the STEM field.

comparative (Figure 11) is an inverted bar diagram distribution at the extremes, in the case of those students who do not want to pursue studies in this field, it is observed how 21.1% consider that their parents do not support them to continue in this field, however, those students who do want to continue their academic stage in this field, indicated in 25. However, those students who do wish to continue their academic studies in this field indicated in 25.1% that they do feel complete support from their family members, which shows the significant importance that having a family figure who encourages them to continue in the scientific-technological field has for them.

To conclude this section of the analysis of the results, a comparative study was carried out with the articles by the authors Ayuso and Alba, since they used the same instrument as previously indicated (Ayuso et al., 2022; Merayo and Ayuso, 2022). In general terms, it was observed that the results obtained in both cases do not differ significantly from those obtained in this study. The conclusions drawn from this comparison will be discussed in the following section.

# 5 Discussion

This section will outline some of the factors that contribute to the lack of motivation among students, particularly female students in STEAM disciplines.

## 5.1 The influence of toys and gender stereotypes

The analysis of the toys preferred by students during their childhood demonstrates a clear division based on gender stereotypes. Female students demonstrated a preference for dolls, skateboards, and puzzles, whereas male students exhibited a predilection for balls, cars/motorbikes, and Legos. This differentiation not only highlights gender stereotypes in toy choice, but also suggests how these stereotypes may influence the development of future STEM-related skills and preferences. Furthermore, it reinforces Lam's assertion that parents may exert an influence on this type of toy choice (Lam, 2023).

## 5.2 Perceived support and role models

Almost half of the students surveyed indicated that they lacked the necessary support from their families or teachers to pursue studies in STEM fields. This lack of encouragement can have a negative impact on interest in these careers. This finding is critical and underscores the need for further analysis and implementation of effective solutions, as close role models have a significant impact on students' future academic decisions, as reflected in research by Rocker Yoel and Dori (2022).

The significance of role models is particularly pronounced in the case of female students. Having role models in close proximity who provide motivation and demonstrate that they possess the requisite skills is of paramount importance in order to enhance their interest in STEM. As Szenkman and Lotitto (2020), have observed, mentoring and early exposure to role models exert a profound influence on girls' self-assurance and personal and career choices.

## 5.3 Academic preferences and perceived barriers

In relation to the main objective of analysing the lack of scientific vocations and the existing gender gap, this study demonstrates a generalised lack of motivation among students, especially girls, to pursue careers in STEM fields. The findings indicate that 65% of male students express a preference for science and technology subjects, in contrast to only 47% of female students. This discrepancy is also evident in students' aspirations to link their future studies to the STEM field. Indeed, 51% of female students indicated a lack of interest in having a connection to this field. Nevertheless, 97% of female students are unambiguous about pursuing their academic careers, in contrast to 88% of their male counterparts. The primary perceived obstacles include a lack of interest and perceived insufficient personal ability, particularly among female students. This phenomenon, which is prevalent among this gender, is exemplified by authors such as Jöstl et al. (2012) and Nelson et al. (2019). Furthermore, the perception that STEM careers do not bring significant value to society also emerges as a barrier, suggesting a need for more information and guidance on the opportunities and impact of STEM careers.

These data confirm the gender gap described in the existing literature, where a lower inclination of girls towards technical studies in secondary education is observed, which is projected towards the field of engineering in the future.

## 5.4 Influence of parents' environment and education level

Family background and the educational level of parents play a crucial role in students' academic choices. Students whose parents have an undergraduate or graduate degree show a greater inclination towards STEM careers, especially if they are related to the STEM field, as reflected in Palmer's studies (Palmer et al., 2017). Perceived parental support is crucial; those who feel fully supported by their families have a greater intention to study STEM subjects. In contrast, those who do not perceive this support have less interest in pursuing these fields, as has been observed in other research, such as that of Ortega-Rodríguez (2022).

In conclusion, this study highlights the urgent need to promote the interest and participation of students, especially girls, in STEM. The main findings highlight a significant disparity between the sexes, which is influenced by several factors, including gender stereotypes, perceptions of personal ability, familial and teacher support, role models in STEM, discrepancies between schools and socio-economic and parental education level.

In light of the study's findings and with a view to enhancing gender equity in STEM disciplines, a series of strategies and practical interventions are put forth for consideration by educational institutions:

1 Integration of STEM role models in the classroom:

- Invite accomplished professionals, particularly women in STEM, to share their experiences with students.
- Incorporate content into the school curriculum that highlights the contributions of women in STEM throughout history.
- Organise regular seminars and lectures featuring inspiring figures from the STEM field.

2 Hands-on experience and early education:

- Implement project-based learning programmes and hands-on activities in primary and secondary schools.
- Develop workshops in robotics, programming, and experimental sciences accessible to all students from an early age.
- Collaborate with technology and science centres to offer extracurricular programmes focused on STEM.

3 Support and mentoring programmes:

- Create mentoring programmes that connect students with STEM professionals for continuous guidance and support.
- Provide training and resources to teachers to raise awareness about the importance of gender equity in STEM and equip them to better support their students.
- Establish support groups for parents and families, providing them with tools to encourage interest in STEM at home.

4 Awareness and mentoring campaigns:

- Develop campaigns that highlight the opportunities and positive impact of STEM careers, with a particular focus on motivating girls.
- Use social media platforms and media outlets to share success storeys and achievements of women in STEM.
- Organise science and technology fairs showcasing innovative projects led by students of both genders.

These strategies are designed to reduce the gender gap and promote greater equity in access and participation in STEM, contributing to the development of a more inclusive and technologically advanced society.

Although this study did not include a detailed analysis of comparisons by student age, nor of the interaction between age and gender, it is recognised that this area of research has considerable potential. A comprehensive analysis in this area would provide more precise data that could identify the specific ages at which a greater shortage of STEM occupations begins to manifest itself. It could also identify the ages at which female students begin to show signs of imposter syndrome or fear of failure, which could lead to a rejection of more technical fields. This approach would not only enrich current knowledge, but also provide a solid basis for developing more effective educational interventions.

As a future line, pilot workshops will be carried out with upper primary school students, to see if at this age it is possible to intervene effectively to prevent the loss of interest in the STEM field or the onset of impostor syndrome and fear of failure.

## Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the participants was not required to participate in this study in accordance with the national legislation and the institutional requirements.

## Author contributions

MH-P: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal Analysis, Data curation, Conceptualization. JA-S: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal Analysis, Data curation, Conceptualization. PH-C: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal Analysis, Data curation, Conceptualization. EQ-G: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal Analysis, Data curation, Conceptualization.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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