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The Impact of Female Role Models Leading a Group Mentoring Program to Promote STEM Vocations among Young Girls

Mariluz Guenaga [1,*], Andoni Eguíluz [1], Pablo Garaizar [1] and Ander Mimenza [2]

[1] Engineering Faculty, University of Deusto, 48007 Bilbao, Spain; andoni.eguiluz@deusto.es (A.E.); garaizar@deusto.es (P.G.)
[2] EDE Foundation, 48010 Bilbo, Spain; amimenza@edefundazioa.org
* Correspondence: mlguenaga@deusto.es

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Abstract: From an early age, girls disregard studies related to science, technology, engineering, or mathematics (STEM), and this means that a gender gap begins during secondary education and continues to increase over time. Multiple causes have been identified for this phenomenon in the literature, and numerous initiatives are being carried out to reverse this situation. In this paper, we analyze the impact that a group mentoring initiative led by a female STEM role model had on the young people who participated and whether the impact was different based on their sex. We analyzed how these mentoring sessions affected their attitudes towards technology, mathematical self-efficacy, gender stereotypes, science and technology references, and career vocations. To this end, 303 students between the ages of 10 and 12 years old from 10 schools in Spain participated in the six sessions comprising the program and completed a series of questionnaires before and after participating. The results show that the program had an impact on the students' attitudes towards technology, increased the number of female STEM references they knew, and improved their opinions of vocations and professions related to science and technology. The impact was greater among girls, although in aspects such as attitudes towards technology, the female participants still demonstrated lower values than boys. The program did not improve the stereotypes that the young participants had about mathematical self-efficacy, which was also always lower among girls. We conclude that the lack of STEM vocations among girls is rooted in multiple social, educational, and personal aspects that need to be addressed from a very early age and that should involve multiple agents.

Keywords: gender; STEM vocation; female role model

1. Introduction

Numerous studies support the existence of a gender gap in STEM (science, technology, engineering, and mathematics) disciplines internationally. Girls, despite having ability in these areas and showing no differences compared to boys in subjects such as mathematics [1], choose science and technology-related studies to a lesser extent than their male peers do. This leads to a loss of STEM skills in young women between secondary and tertiary education [2]. In addition, boys in the 6th grade and at the university level show more interest in technology than girls do at all ages [3].

In terms of interest in science and technology, studies in the UK show that most children up to the age of 16 like technology but do not consider the professions of scientist or engineer to be desirable careers [4]. This difference is first found in primary school and becomes more pronounced in secondary school. Similarly, interest in science and technology is higher among young men (19%) than among young women (14%). Moreover, 21% of young men aged 15–24 report a high level of scientific and technological education, compared to 18% of young women. However, since 2008, interest has grown more among young women than it has among young men, with an increase of 7.8 and 5.8 percentage points, respectively [5]. On the other hand, being technology users seems to be unrelated to an interest in these professions. Young girls and boys use technology daily, but girls are not involved in its development to the same extent. Examples of this are space exploration [6] or the video games sector, where 46% of gamers are female [7] but only 24% are involved in their development [8]. Children aspire to develop those professions that they are exposed to within their environments or that come to them through the media [9], but there are countless professions that they are unaware of, including many that are linked to engineering, technology, mathematics, or research.

This reality is also true in Spain, and it is reflected in higher education. The number of students opting for university education in technology decreases every year [10]. Although 56% of the students who enrolled in the 2019–2020 academic year in undergraduate and first- and second-cycle studies were young women, they only represented 25% of the students enrolled in engineering studies. However, the percentage is reversed in Health Sciences, where more than 70% of those enrolled were young women [5].

The STEM pipeline is losing female talent throughout the education system [11]. Thus, fewer than 10% of computer science graduates were female in the 2017–2018 academic year, while in education, the total of female graduates exceeded 70%, and this trend has not improved over the years. At the Master's level the percentage of female graduates in engineering and architecture was 33.9% in 2012–2013, and it decreased by more than one point (32.3%) by 2017–2018 [12].

The lack of young women in STEM studies is consequently reflected in the labor market. The percentage of men and women working in science and technology is 3.1 for women compared to 4.5 for men [13]. This same report shows us that the data at the European level do not vary in the Spanish reality. As they advance in academics, women are less represented, and the so-called scissors effect occurs, with a higher percentage of women being present in the initial stages and decreasing until the trend is reversed in the final stages, with more men than women in positions of responsibility. If we focus on STEM-related fields, the gap between women and men is even wider, with the percentage of men and women never being equal, and this gap increases as one's career progresses. Young women represent 37% of PhD students and 39% of PhD graduates but hold only 15% of the top academic positions.

It is important to know these figures because they not only help to measure the scope and evolution of the problem, but also to raise awareness to combat resistance to, and illusions of, equality among those who seek to justify inaction or even advocate for regression in equality policies.

The situation arising from the global COVID-19 pandemic has further highlighted the importance of science and technology for the development of the knowledge economy and the need for STEM professionals. According to The Future of Jobs Report 2020 [14], more professionals will be needed in areas related to cloud computing, data and artificial intelligence, engineering, and content production, in the future. As a result, numerous initiatives are aimed at fostering STEM vocations among young people, especially among girls. The question that may arise here is why we need these initiatives to increase the presence of women in these areas. It is necessary to attract young people to STEM studies, young women in particular, not only to increase the number of STEM-trained professionals, but also to increase the diversity among these professionals [15].

Encouraging female vocations and diversity in teams (in this case, we are dealing with gender diversity) is not a whim. The absence of women in science and technology has consequences. For example, one of the consequences is the bias in artificial intelligence algorithms that has already been seen to grant lower lines of credit to women than to men despite equal or better solvency indicators [16]; in the recognition of images that associate objects, such as hammers to men and brooms to women [17]; and in urban design and development, which affects the safety and well-being of women in cities [18]. Research by Agudo and Matute shows that people are willing to endorse the suggestions that algorithms make and that our biases make us vulnerable to them. Consequently, the number of biases that an algorithm could exploit is immense. These biases occur in a multitude of sectors and application areas, with minorities often being excluded [19,20]. However, not only that, the Sustainable Development Goals (SDG) reflect the priorities of the United Nations (UN) and they are based on decades of work done by countries and the UN. They represent an action plan in favor of people, the planet, and prosperity, which also intends to strengthen universal peace and access to justice. Among the 17 sustainable goals defined, the fifth is specifically: "Achieve gender equality and empower all women and girls" (SDG5). In addition, SDG4 "Guarantee inclusive and equitable quality education and promote lifelong learning opportunities for all" points out two specific targets aligned with female STEM vocations: "By 2030, ensure equal access for all women and men to affordable, quality technical, vocational and tertiary education, including university" and "By 2030, significantly increase the number of youth and adults with the skills, including technical and vocational skills, needed for employment, decent work and entrepreneurship". Therefore, promoting STEM vocations among girls conducts to a more sustainable society.

Additionally, knowing the characteristics of students who have been successful in their engineering studies can help us understand the motivations that have led them to these achievements. In his study, Engström [21] identified the following aspects: (1) a genuine interest in natural sciences from childhood, (2) high self-confidence in mathematics, (3) a positive view of classroom education, (4) a positive view of the role of the engineer, and (5) a view of higher technical education as a pathway to something "for me".

To reverse the gender gap in STEM, it is necessary to understand the causes of this gap. Authors such as Archer [4] have developed a model that identifies some of the factors that shape the scientific identities and aspirations of 10- to 19-year-olds. These causes are rooted in inequalities related to scientific capital, dominant educational and social representations of science (masculine and intelligent), and educational factors and practices. The interest and vocation that women have in science is similar to a leaky pipeline at many points during their personal and professional development [11]. This problem has multiple causes, and even if these causes interact with each other and there is no single root cause [22], there are clearly influential aspects, which are described below.

1.1. Gender Stereotypes

Gender identity is defined as a psychological component that shapes one's ideas about a person's masculinity and femininity [23]. Gender is continuously constructed and negotiated through an individual person's personality, interactions with others, communities, and culture [24]. Through a process of socialization, men and women internalize these stereotypical characteristics that become part of their self-concepts, and they develop different expectations, aspirations, and abilities to conform to social roles [25]. Stereotypical gender role characteristics may be a crucial determinant of women's low achievement motivation and negative performance expectations. These determine the future career aspirations of women, which are shown to be lower than those of men [26].

Stereotypes are shaped from a very young age, while gender identity is defined. As early as age 2, girls show a greater liking for the color pink than boys do. The problem is not the color pink, but what it represents: the label "I am a girl" and the limiting expectations this entails [27]. Other studies support the fixation of gender stereotypes from an early age. Shenouda and Danovitch [28] designed an experiment involving a spatial task with Lego and found that girls who believe that Lego is for boys were slower in building skills tests. In the same vein, a study by Girlguiding in the UK showed that more than half of girls and young women aged 7–21 said that gender stereotypes affect their ability to say what they think [29]. In turn, the study by Bian et al. [30] supports this thesis by showing that, at age six participants associate high-level intellectual ability (brilliance, genius, etc.) with boys rather than with girls. This stereotype shapes children's interests and is likely to narrow the range of studies and professions that girls will one day contemplate. The influence of stereotypes also seems to be influenced by age or the area, rural or urban, where young people grow up [31]. In this study, Raquel Fernández and her team analyzed the responses of more than 400 students aged 13–18 years old and saw that there was a higher percentage of disagreement with stereotyped ideas in students at the high school (90% of agreement) rather than in students at the secondary compulsory education level (71% of agreement), and that students from urban schools showed a higher percentage of disagreement with stereotyped ideas (81%) compared to the percentage of disagreement of students from rural schools (69%).

In STEM fields, stereotypes are reinforced by the continuing shortage of women in these fields [32]. Stereotypes about women's abilities in STEM exist at both the conscious (explicit) and unconscious (implicit) levels and both have consequences: They cause others to negatively value women in these areas and they cause women themselves to have poorer performance (grades), lower identification with these areas, lower interest in these studies, and higher anxiety [33]. Additionally, when women give negative criticism to their employees, the effect has twice the magnitude as when the criticism is given by male leaders [34].

Persistent negative stereotypes of women in STEM have led to the so-called stereotype threat and make women feel intimidated in these areas. This threat causes a decrease in performance; individuals feel threatened by the possibility that their performance will confirm—to others and/or themselves—a negative stereotype about their group abilities [35]. In particular, the threat of being negatively stereotyped in mathematics harms the performance of highly skilled women on difficult mathematics tests. This even affects girls who deny being stereotyped. The study by Huguet and Régner [36] with 200 middle school girls (11–13 years) shows that girls feel intimidated when faced with geometry problems and perform better when the same challenge is labeled as a drawing problem.

Therefore, promoting a social environment in which women can identify with other successful female role models in science, technology, and mathematics could help to change stereotypes about women. Current findings suggest that stereotypes about women are not fixed and change over time [37]. A reflective identification process may be able to change the attitudes that women have towards their STEM skills [33], and direct interaction—not online or not through readings—with STEM references may be a key component to changing how women identify with STEM [38–42].

1.2. Missing Female Role Models

There is a gap between the perception that many students have of scientific professions and what they really entail [31]. When we look at the profile of students who have chosen STEM studies, we see that those who have opted for engineering have parents—and especially mothers—with a high level of education (usually in science and technology) and a positive outlook towards that profession [22]. The reverse is also true: girls report less support from their parents to pursue technology and are less likely than boys to aspire to technology careers [4].

Zawistowska conducted a study in Poland with 20 female engineering and technology students who agreed that the choice that women make to pursue stereotypically masculine careers is related to the presence of a significant role model in their close social network [42]. In this case, a role model is defined as a person who is more advanced in technology or engineering and who has a long-lasting interaction with the individual making the decision. According to this study, a role model in STEM "infects" other individuals in their social network with the idea of pursuing STEM-related careers.

The role model provides accurate information that allows students to realistically estimate the potential costs and benefits of making a decision that goes against gender role stereotypes. The decision to pursue a career in STEM is a process that begins relatively early in life and that then must be maintained on an ongoing basis.

Several programs use science and technology role models to improve student attitudes towards these areas. Ashby Plant et al. [43] used virtual role models (male, female, and no role model) to change the attitudes of secondary school students (12–15 years old, N = 106) towards engineering-related fields, their self-efficacy in those fields, and their mathematics performance. The female agent increased the interest, usefulness beliefs, self-efficacy, and mathematics performance of both girls and boys; in the case of boys, the female agent also decreased stereotypes (which was not the case among girls). The Inspiring Girls Foundation puts young students in contact with actual female role models with a successful professional trajectory in STEM fields. Within this program, Susana González and her team developed a study with 304 students, aged 12–16 years old, in Spain and showed an impact in reducing stereotypes and of boosting motivational factors, which play an important role in the engagement that girls show in STEM fields [38]. Girls4STEM is an initiative developed also in Spain with students in primary and secondary education and the main objective of Family Talks, in particular, is to learn about the daily life of a professional STEM woman [39]. The results of the impact analysis of this initiative showed the need to clarify the meaning of STEM areas, the girls' less confidence about their performance in STEM disciplines, and the need to start addressing this issue from early childhood. Technovation is an international program with a chapter in Spain [40]. In this case, girls develop mobile apps with the help of volunteer mentors to address problems in local and global communities. The impact analysis of the program over 41 participants showed that Technovation increased some alumni's confidence in studying computer science but deterred others; they took leadership roles and influenced peers and they were more confident in teamwork skills than programming skills. A study developed by Microsoft with 11,570 students showed that role models clearly have a positive impact on girls' perceptions of STEM subjects. On average, across Europe, 41% of girls with role models reported an interest in STEM subjects compared to 26% of girls without a role model [41].

1.3. Self-Concept and Aspirations

Young people have the perception that scientific and technological studies are difficult. This is supported by the performance rate: the percentage ratio between the number of credits passed and the number of credits enrolled. In Spanish universities, the average performance rate of undergraduate students in the 2017–2018 academic year was 77.8%, reaching its minimum in the engineering and architecture branch (67.5%) and its maximum in the health sciences branch (84.7%) [12]. This relates to one of the key factors in understanding the low amount of interest that girls have in STEM fields, i.e., self-concept, and the impact that this has on their career aspirations. However, the data provided by the Spanish Ministry show that in science and technology studies, young women perform equally as well as, or better than, young men. During the 2017–2018 academic year in Spain, the performance rate (percentage ratio between the number of credits passed and the number of credits enrolled) in degrees such as engineering and architecture was 71.9% for young women and 66% for young men; the dropout rate in the first year of these studies was 19.8% for young women and 26.6% for young men, and the average grade of graduates was 6.85 and 6.83, respectively.

For decades, numerous studies have endeavored to demonstrate the biological brain differences between women and men in relation to their abilities, and some of them are of dubious methodological quality [44]. In their study, Ashby Plant et al. [43] observed that students' performance in mathematics and their interest in an engineering-related career was due to their perceived self-efficacy. That is, by making young students more confident in their engineering-related skills, the female agent helped increase the students' mathematics test scores and their interest in pursuing mathematics and the hard sciences. Sáinz and Eccles also found that boys have a higher self-concept in their math ability despite the lack of gender differences in math performance [45]. These findings highlight the importance of self-efficacy to achievement and motivation, and indicate that interventions targeting self-efficacy can help boost achievement and interest.

Unfortunately, objective results on mathematics performance do not always match girls' perceptions and self-concepts of their abilities. Stereotypes associate high-level intellectual ability (brilliance, genius, etc.) with males rather than with females. In the study developed by Bian et al. [30] with 400 girls and boys, it was observed that at the age of six, stereotypes already support this judgement. Girls avoided activities designed for "very, very smart" people and stated that these were for boys. However, there were no differences in the games that were designed for "hard-working children." These findings suggest that gendered notions of brilliance are acquired early and have an immediate effect on children's interests as they begin to make decisions about their future at school age. This is why intervention is needed from early childhood. Additionally, Ashby Plant et al. [44] found that negative self-efficacy beliefs about engineering-related skills start early, in primary school, and that the negative implications may resonate throughout their academic and professional careers.

The dominant association of "intelligence" and "masculinity" is detrimental and makes many young people feel that science is "not for me" [4]. According to these authors' findings, gender plays a very important role in aspirations and identities related to technology, engineering, and mathematics. The young women who aspired to study engineering in the study distinguished themselves (compared to young women in general and to young men who aspired to engineering) as having exceptional confidence in their academic abilities in the field of science. In other words, a woman must be exceptionally confident to be eligible for engineering studies. Additionally, we again see that the students who are the least likely to express high self-confidence in mathematics were young women.

This situation led us to design a program to encourage young women to be interested in science and technology. Through six classroom sessions that were mainly developed by close female STEM references and by following the group mentoring methodology, the Inspira STEAM program aims to work on some of the issues that have been identified as barriers preventing girls between 10 and 12 years old from accessing scientific-technological areas. The Inspira STEAM references are female professionals in science and technology who are nearby and who act as STEM role models in the community. Within the frame of this work, we posed the following research questions:

RQ1. Does a group mentoring program facilitated by a close science and technology professional positively influence attitudes towards technology, mathematical self-efficacy, gender stereotypes, STEM references, and aspirations for the career vocations of young people?
RQ2. Do the attitudes that young people have towards technology, mathematical self-efficacy, gender stereotypes, STEM references, and vocational aspirations differ according to their gender?
RQ3. Does a program such as Inspira STEAM have a different impact depending on the gender of the participant?

1.4. The Inspira STEAM Program

After having analyzed the various causes that limit the access that girls have to STEM and seeing that it is necessary to intervene at an early age [4,43], we designed the Inspira STEAM program to promote scientific and technological vocations among young people, especially among girls aged 10–12 years (6th grade of primary and 1st year of secondary in the Spanish education system). The program focuses on areas of science and technology where there is a gender gap (e.g., engineering, mathematics, or vocational training in industrial or technological fields). However, all STEM areas are discussed throughout the six sessions. We also wanted to highlight the relationship between STEM and other fields of knowledge, its transdisciplinary nature, and its application to all aspects of our lives. This is why we named the program Inspira STEAM, with the A representing arts.

Inspira STEAM develops a logic model, shown in Figure 1, which is based on some of the causes that have been identified in the literature as limiting the access that girls have to science and technology, that is designed to address the causes of these limitations and aims to impact specific aspects over the course of a six-session intervention. Among the very diverse causes that were identified, Inspira STEAM specifically addresses the following: C1. Lack of knowledge of what STEAM is and its relevance to overcoming the small and big challenges of our society; C2. The limiting gender stereotypes in science and technology that condition the behavior and decisions of young people, especially girls; C3. Lack of awareness of the wide range of sectors and environments in which STEM professionals can develop their careers; C4. The lack of female role models in science and technology, historical, current, and nearby, as well as the causes of their invisibility; and C5. Self-concept, judgements about one's own skills (mathematics), and how this influences girls' expectations and aspirations.

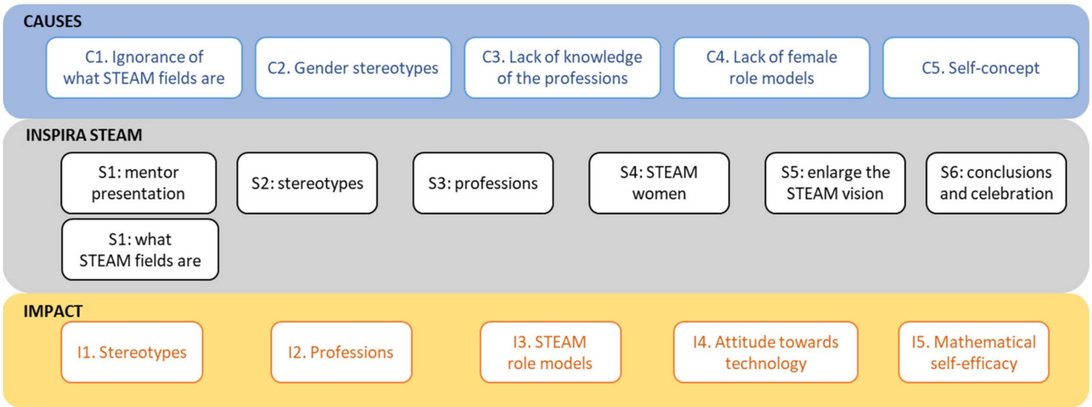

Figure 1. Inspira STEAM logic model, which describes the causes addressed, the intervention, and the measurement of impact.

To address these causes, we designed a six-session program: S1 (session 1). Introduction of the mentor and the young people and introduction to what STEM is and where it is in our environment; S2. Gender stereotypes in STEM areas; S3. Scientific and technological professions and the knowledge and skills needed for their development; S4. Historical, current, and nearby women in STEM and their contributions to science and technology; S5. Broaden the view on these areas and connect them with societal challenges as well as with the interests of young people; and S6. Closing session, conclusions, sharing of learning, and celebration of the experience with the mentors.

The hypothesis of our study is that the Inspira STEAM program can have a positive impact on: I1. Gender stereotypes; I2. Career aspirations; I3. Famous or surrounding STEM references; I4. Attitudes towards technology; and I5. Mathematical self-efficacy.

Inspira STEAM is developed over six sessions in the classroom, lasting approximately one hour and during school hours to reach all students. These sessions are held one or two weeks apart and are mainly facilitated by women and by a few men (mentors) who are professionals in science and technology and with a more or less extensive professional career, who participate in the program on a voluntary basis.

The first time that these mentors participate, they receive an 8-h training period, in which (i) guidelines are given on how to facilitate the classroom sessions following the one-to-many group mentoring methodology [46]; (ii) the gender perspective of the program is transferred; and (iii) the materials we designed for students and mentors (scripts, workbook, complementary material, etc.) are presented. Mentors are recruited through dissemination campaigns on social networks, organizations and participation in events, media, and word of mouth among the mentors who have participated in previous editions.

Additionally, we conducted a dissemination campaign to reach schools that may be interested in participating in the program with their 6th grade or 1st-year secondary school groups. Schools participate free of charge; they only have to provide a paper copy of the workbook to each student. The school staff supports the work of the female mentors and only rarely facilitates these sessions with the male students in the school. The girls always work with a female mentor and the boys work with a female mentor, a male mentor, or, if neither is possible, with a teacher from the school who also receives the training.

Once the mentors have been trained and the schools have registered on the project website, we assign mentors to the groups of students. Each group is assigned two people to facilitate the program. Sessions one and six are carried out by the whole group together with the two people assigned, while sessions two to five are divided and are carried out separately: the girls with one mentor and the boys with the other mentor if possible, or with a person from the center in the few cases in which it is not possible to work with a mentor. In this way, we ensure that the girls always have a female mentor and that the groups we work with are not large (<15 students). The criteria through which the mentors are assigned to the schools are the geographical location and the language in which the program will be carried out (Spanish, Basque, or English).

Once all the mentors approve their participation in the program, we put them in contact with the schools so that they can schedule the six sessions in the classroom according to the timetable of the assigned group and the availability of the mentors. Throughout the program, the Inspira STEAM coordination team provides support to the participants and monitors and resolves any incidents that may arise. We also collect feedback from the participants to both learn about the strengths and weaknesses of the program and to identify areas for improvement for future editions.

2. Materials and Methods

2.1. Participants

During the 2020–2021 academic year, a total of 10 schools (six in the Basque Country, two in Madrid, and two in Barcelona) participated in the research. The schools participated voluntarily and free of charge, and the students had the consent of their legal guardians. Of the 10 schools, seven were public and three subsidized. In terms of the size of the school, two schools only had one group, four schools had two groups, two schools had five groups, and two schools had six groups.

The 10 schools resulted in 600 students being involved in the study. To not overload the students, they answered the pre- and post-questionnaires in two blocks (Block 1: sociodemographic data, mathematical self-efficacy, and professions and Block 2: sociodemographic data, attitude towards technology, gender stereotypes, and STEM references). A total of 303 students correctly completed the pre- and post-questionnaires in Block 1 (50%), and 344 completed the Block 2 (57%) questionnaire. The study only analyzes data from the students who answered both the pre- and post-questionnaires. The rest of the answers were discarded because they were incomplete.

Among the participants, 47.9% were girls and 49.5% boys; the rest did not state their gender. The mean age was 11.69 years (SD = 0.616), and they were in sixth grade (47.9%) or first grade (52.1%). In total, 196 students participated in the experimental group, and 107 participated in the control group. Regarding the configuration of the groups during sessions two to five, 89% of the students in the experimental group worked in separate girls' and boys' groups, while the rest always worked in mixed groups (due to organizational issues at the school). In 80% of the cases, the sessions were facilitated by a female mentor, while in 5% of the cases they were facilitated by a male mentor. In the schools where an external mentor could not be provided, the participants worked with a person from the school; 11.6% of the students worked with a female teacher from the school, and 2.6% with male a teacher.

2.2. Tools

In accordance with the five key aspects that were previously identified as causes of girls having a low interest in STEM areas and the objectives defined in Inspira STEAM, we proposed a study to analyze the impact of a group mentoring program in which a STEM reference person, usually female, worked on these aspects in the classroom. In particular, we wanted to analyze the impact of these sessions on gender stereotypes, professional aspirations, famous or environmental STEM references, attitudes towards technology, and mathematical self-efficacy.

To measure gender stereotypes, we used the questionnaire by Colás Bravo and Villaciervos Moreno [47]. The aim of this instrument is to identify the cultural representations (stereotypes) of gender that have been internalized by young people and by adolescents in secondary education. The research team revised the language and wording to adapt it to the 10- to 12-year-olds participating in Inspira STEAM, with the aim of making the language more similar to language that is commonly used in their daily lives. Adjectives such as "audacious and intrepid" were replaced by others that are more common in their vocabulary, such as "determined and brave."

The instrument consists of 21 items whose response options have been expanded from the original Yes/No to a four-value scale (strongly disagree, disagree, agree, and strongly agree) to obtain a broader range of student responses. Examples from the questions include "women should take more care of their appearance and beauty than men", "boys are better in scientific-technical careers (engineering, physics, chemistry, mathematics, etc.)", and "women usually solve conflicts by using dialogue, by talking". This questionnaire showed good internal consistency ($\alpha = 0.954$), higher than the original by Colás Bravao and Villaciervos Moreno ($\alpha = 0.7805$).

The mathematical self-efficacy measure is an adaptation of the instrument developed by Schwarzer and Baessler [48], which was adapted by the research team, the General Self-Efficacy Scale, which assesses the stable feeling of personal competence to effectively handle a wide variety of stressful situations. In this case, we focused on mathematics. The questionnaire consists of 10 items with four response options (incorrect, barely true, rather true, and true). Some questions are: "I can solve most mathematical problems if I try hard enough", "Thanks to my qualities, I can overcome unexpected situation", and "I can solve difficult mathematical problems if I try hard enough". The questionnaire showed good internal consistency ($\alpha = 0.89$), higher than the original ($\alpha = 0.81$) and that of other studies that have subsequently validated it in a university population ($\alpha = 0.87$) [49].

The questionnaire to measure attitudes towards technology is one of the four subscales of the instrument developed by Kier et al. [50], specifically, the subscale related to technology. This subscale includes 11 items (e.g., "I am able to do well in activities involving technology" or "I am interested in professions that use technology"), which are responded to using a 7-point Likert scale ranging from 1—strongly disagree to 7—strongly agree. This instrument showed good reliability ($\alpha = 0.868$), although it was somewhat lower than that obtained by its authors ($\alpha = 0.89$).

To determine the students' professional aspirations, an open-ended questionnaire was designed to ask: "Indicate up to three options in order of priority (one per row), what would you like to work in when you grow up?" These answers were coded according to their closeness to scientific and technological areas and the gender gap they represent: 0—no relation to technology, 1—health sciences, such as medicine, nursing, psychology, or veterinary, 2—sciences without a gender gap, such as biology, architecture, geology, or paleontology, 3—technological professions associated with the creation, use, or distribution of content, such as YouTubers, gamers, or video game designers, and 4—STEM professions with a gender gap, such as jobs related to computer science, engineering, or mechanics.

In the case of the referents in science and technology, students were asked to write the name of a maximum of five people who are involved in science or technology and to indicate if these were nationally or internationally recognized people or a person from their close social environment.

2.3. Process

The study was developed during the 2020–2021 academic year. We held individual meetings and engaged in email communication with school leaders to explain the objective and need for the research, the process to be followed with their students, and the tools we were going to use, as well as to resolve any doubts before and during the process.

Subsequently, each school was asked to specify the groups that would participate in the research. To facilitate the organization, groups that had been formed previously (e.g., 6th grade A, 6th grade B, etc.) needed to work together. This restriction was even greater due to the pandemic and the bubble groups that had to be strictly respected for security reasons. The schools, based on the organizational criteria, decided which groups would be the experimental ones, engaging in the first phase of Inspira STEAM in the first phase, and which groups would go on to the second phase, the control groups (see Figure 2). Finally, the dates were set for each group to complete the pre-test and post-test. Except for one case, the questionnaires were completed through an online platform.

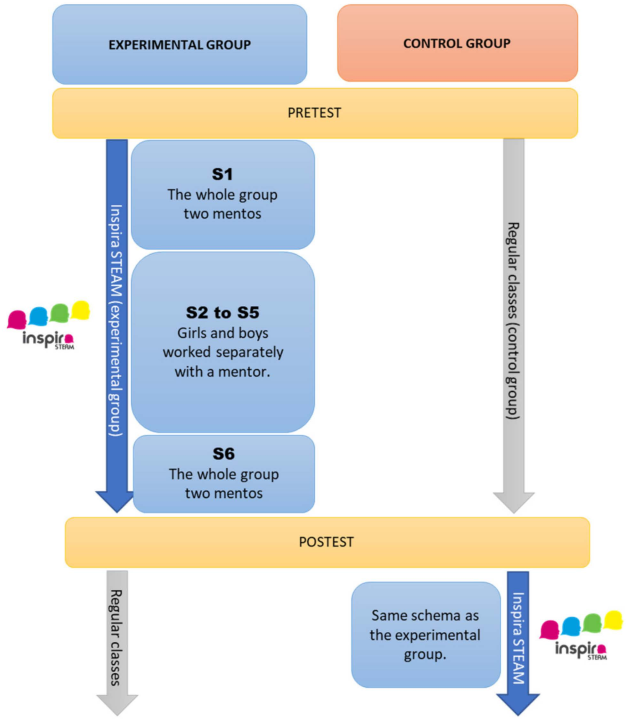

Figure 2. The method followed in this study; it shows when the experimental and control groups answered the pre- and post-questionnaires and when they participated in Inspira STEAM.

The experimental group then participated in the six Inspira STEAM sessions, while the control group continued with their regular classroom activities. Once the experimental group finished the last session, all of the groups answered the post-tests. Finally, the control group participated in Inspira STEAM, so as not to disadvantage any student and so that all of the students could benefit from the experience.

Once the responses were collected in .csv files, they were filtered, and the pre-test and corresponding post-test were matched. These valid data were analyzed using SPSS.

3. Results

In this section, we show the main analyses and results of the questionnaires completed by the students participating in Inspira STEAM. To answer the research questions, we matched the data obtained from the pre- and post-tests for each student and compared the data from the experimental and control groups, as well as by gender.

3.1. Mathematical Self-Efficacy

To determine the existence of different mathematical self-efficacy values between the students who participated in Inspira STEAM and those who did not, we analyzed the difference of means in paired samples between the control group and the experimental group and did not find any significant differences (see Table 1). The response to the question "Come what may, I am able to handle it" showed an increase in the experimental group of girls (0.22, $p < 0.05$) that did not occur in the control group (−0.019). In the case of the boys, the item in which the experimental group stood out with respect to the control group was "I can find a way to solve any math challenge I want, even if someone opposes me" (0.21, $p < 0.05$). The difference in means by gender was not significant, but in all the measurements, the mean for the girls was lower than that for the boys in terms of mathematical self-efficacy.

Table 1. Mathematical self-efficacy, average by gender.

		Girls	Boys	The Whole Sample
Experimental group	Pretest	2.91	3.10	3.00
	Posttest	2.98	3.13	3.05
	Difference	0.07 (N = 91)	0.03 (N = 100)	0.05 (N = 196 *)
Control group	Pretest	2.85	3.03	2.94
	Posttest	2.90	3.09	2.97
	Difference	0.05 (N = 54)	0.06 (N = 50)	0.03 (N = 107 *)

* There were five students in the experimental group and three in the control group who did not declare their gender.

3.2. Attitude towards Technology

We analyzed whether there was a difference in the attitudes towards technology between the experimental and the control group (see Table 2). To do so, we performed an analysis of the difference of means in the paired samples, which showed that the experimental group had a significant improvement in its result (0.19, $p < 0.05$) with respect to the control group (0.01, $p > 0.05$). We saw a significant improvement in the following items: "My parents would like me to choose a technological profession" (0.47, $p < 0.01$), "I know someone in my family who uses technology in their work" (0.42, $p < 0.01$), and "I am interested in professions that use technology" (0.46, $p < 0.01$).

Table 2. Attitude towards technology, by gender.

		Girls	Boys	The Whole Sample
Experimental group	Pretest	5.06	5.55	5.29
	Posttest	5.39	5.57	5.48
	Difference	0.33 * (N = 103)	0.02 (N = 106)	0.19 * (N = 211)
Control group	Pretest	5.26	5.50	5.34
	Posttest	5.22	5.49	5.35
	Difference	−0.04 (N = 55)	−0.01 (N = 64)	0.01 (N = 124)

* ($p < 0.05$).

The difference in the means of the girls was even greater in the experimental group (0.33, $p < 0.01$). The items that contributed the most to this difference were "I plan to use technology in my future job" (0.45, $p < 0.05$), "My parents would like me to choose a technology profession" (0.57, $p < 0.01$), "I am interested in professions that use technology" (0.63, $p < 0.01$), "I know someone who uses technology in their job" (0.40, $p < 0.05$), "I would feel comfortable talking to people who have a technology profession" (0.544, $p < 0.05$), and "I know someone in my family who uses technology in their job" (0.64, $p < 0.01$).

In the boy group, the difference in means was not significant as a whole, but it was significant for the item "My parents would like me to choose a technological profession" in the experimental group (0.39, $p < 0.05$).

Again, the boys obtained higher scores in their attitude towards technology in all the means analyzed.

3.3. Gender Stereotypes

To determine the impact of Inspira STEAM on gender stereotypes, we analyzed the difference in means in the experimental and control groups, and we performed the analysis disaggregated by gender. In the analysis of the difference of means in the paired samples (see Table 3), we saw a small improvement, but it was not significant in either the control group (−0.07, $p > 0.05$) or in the experimental group (−0.02, $p > 0.05$). There was a significant difference in two of the items of the scale, specifically in "Women usually resolve conflicts using dialogue, talking" and "Men tend to have more competitive attitudes." The experimental group improved with respect to gender stereotypes (−0.18, $p < 0.05$), but the control group did so to a greater extent (−0.27, $p < 0.01$), whereas in the second item, the experimental group improved its result (−0.17, $p < 0.05$) to a lesser extent than the control group did (−0.29, $p < 0.01$).

Table 3. Gender stereotypes by gender.

		Girls	Boys	The Whole Sample
Experimental group	Pretest	1.59	1.86	1.72
	Posttest	1.53	1.87	1.70
	Difference	−0.06 (N = 104)	0.01 (N = 106)	−0.02 (N = 212)
Control group	Pretest	1.59	1.93	1.76
	Posttest	1.49	1.88	1.68
	Difference	−0.10 * (N = 55)	−0.05 (N = 64)	−0.07 (N = 124)

* ($p < 0.05$).

The experimental group of girls improved in terms of their stereotypes, but it was not a significant improvement (−0.06, $p > 0.05$). On the contrary, in the control group, the improvement was greater (−0.10, $p < 0.05$). In the full sample, the girls in the experimental group improved significantly in the item "Women usually solve conflicts by using dialogue, by talking" (−0.27, $p < 0.01$), and in the case of the girls in the control group, the improvement was greater (−0.30, $p < 0.5$).

Finally, as we see in Table 3, the results show that the girls in all of the groups have less gender stereotypes, which was also the case at all of the analyzed time points.

3.4. STEM References

We asked the students about the science and technology references that they know of (C&T), both recognized and nearby. We grouped their answers, a maximum of five, and saw that the experimental group increased by 12.1 points in terms of the number of known female references after participating in Inspira STEAM (see Table 4). In addition, they reported knowing more STEM women in their immediate environment, 2.8% more than before participating in the program. The control group also increased in terms of the number of female references, but much less than the experimental group.

Table 4. Female and male referents, both well-known and close, of the experimental and control groups.

Type of Referent	Experimental Group			Control Group		
	Prestest	Posttest	Dif.	Prestest	Posttest	Dif.
Well-known men in C&T	35.0%	26.2%	−8.7	31.5%	28.0%	−3.5
Well-known women in C&T	11.0%	23.0%	12.1	8.1%	11.7%	3.6
Close men in C&T	23.8%	21.2%	−2.6	32.3%	30.4%	−1.9
Close women C&T	19.1%	21.9%	2.8	20.6%	21.5%	0.9
No C&T	11.1%	7.8%	−3.3	7.5%	8.4%	0.9

Dif: difference.

As we can see in Table 5, the girls in the experimental group had the highest increase in recognized female referents (13.6 points). They listed female referents (49.3%), known or close to them, in a higher percentage than they did male referents (48%). However, this was not the case for the girls in the control group (60.2% listed males vs. 38.8% females), boys in the experimental group (49.6% vs. 40%), and boys in the control group (55.9% vs. 28.7%). Finally, students in the experimental group reported knowing more female STEM references in their environment than the control group did. A total of 24.0% of the girls in the experimental group had close female referents in contrast to 21.3% of the boys in the experimental group, while in the control groups, these percentages were 21.4% and 19.7%, respectively.

Table 5. Female and male referents, both well-known and close, of the experimental and control groups.

Type of Referent	Girls Experimental Group			Girls Control Group			Boys Experimental Group			Boys Control Group		
	Pre	Post	Dif	Pre	Post	Dif	Pre	Post	Dif	Pre	Post	Dif
WkM-C&T	32.4%	24.0%	−8.4	26.1%	27.4%	1.3	37.3%	28.7%	−8.6	35.6%	26.7%	−8.9
WkW-C&T	11.7%	25.3%	13.6	10.3%	16.4%	6.1	10.4%	20.3%	9.9	6.2%	7.4%	1.2
CM-C&T	25.2%	21.6%	−3.6	35.8%	32.8%	−3.0	22.3%	20.9%	−1.4	30.5%	29.2%	−1.3
CW-C&T	23.0%	24.0%	1.0	24.2%	21.4%	−2.8	15.0%	19.7%	4.7	16.4%	21.3%	4.9
No C&T	7.8%	5.1%	−2.7	3.6%	2.0%	−1.6	15.0%	10.4%	−4.6	11.3%	15.4%	4.1

WkM-C&T: well-known men in C&T; WkW-C&T: well-known women in C&T; CM-C&T: close men in C&T; CW-C&T: close women C&T; No C&T: not related to C&T; Pre: pre-test, Post: post-test. Dif: difference.

3.5. Professions

Each student was asked to indicate what they would like to be when they grow up and provided a maximum of three open-ended responses. We coded and grouped the responses according to their closeness to STEM professions with a gender gap (Prof-4), STEM professions related to content design and creation (Prof-3), STEM professions that do not have a gender gap (Prof-2), biosanitary professions (Prof-1), and professions not related to STEM (Prof-0). In Table 6, we see the percentage difference in the post-test with respect to the pre-test. The experimental group reduced the non-STEM options significantly, from an initial 66.7% to 62.4%. This percentage did not decrease, but it grew slightly (0.3) in the control group. Students in the experimental group increased their preference for professions in the STEM branches in which there is no gender gap (2 points), design and content creation (2.2 points), and in STEM professions with a gender gap (1.3 points). This percentage did not vary in the control group.

Table 6. Percentage of students who chose each of the experimental and control group career options grouped by the five responses.

Type of Profession	Experimental Group			Control Group		
	Prestest	Posttest	Dif	Prestest	Posttest	Dif
Prof-0	66.7%	62.4%	−4.3	67%	68%	0.3
Prof-1	8.7%	7.4%	−1.3	10%	9%	−0.9
Prof-2	3.1%	5.2%	2.0	3%	5%	1.3
Prof-3	4.2%	6.4%	2.2	3%	3%	−0.6
Prof-4	17.3%	18.6%	1.3	16%	16%	0.0

Prof-0: no-STEM professions, Prof-1: biosanitary, Prof-2: STEM without gender gap, Prof-3: digital content design and creation, Prof-4: STEM professions with gender gap. Diff: difference.

Boys in the experimental group were the ones who mainly reduced their preference for non-STEM professions (from 59.5% to 52.5%). They increased their interest in more traditional STEM professions without a gender gap (Prof-3, 1.3 points), STEM professions with a gender gap (Prof-4, 1.4 points), and, mainly, those professions related to design and content creation (Prof-3, 5 points). Boys in the control group worsened their preferences in STEM in general and, above all, in those with a gender gap (Prof-4). They shifted their preferences to the more traditional STEM professions (Prof-2).

The non-STEM option was the option that the majority of the girls chose, exceeding 70% in both the experimental and control groups; there was a difference of more than 10 points with respect to boys (see Table 7). After participating in Inspira STEAM, girls reduced this percentage by 1.2 points (from 73.8% to 72.6%) in favor of traditional STEM professions (an increase of 2.9 points) as well as those with a gender gap (Prof-4) (from 10.5% to 11.1%). However, the increase was greater in the latter professions among girls in the control group (1.3 points).

Table 7. Percentage of students opting for the different professions, grouped by gender and group.

TP	Girls Experimental Group			Girls Control Group			Boys Experimental Group			Boys Control Group		
	Pretest	**Posttest**	**Dif**	**Pretest**	**Posttest**	**Dif**	**Pretest**	**Posttest**	**Dif**	**Pretest**	**Posttest**	**Dif**
Prof-0	73.8%	72.6%	−1.2	77.0%	76.3%	−0.7	59.5%	52.5%	−6.9	58.8%	59.3%	0.5
Prof-1	10.9%	8.9%	−2.0	11.2%	10.0%	−1.2	7.2%	6.4%	−0.8	10.1%	9.3%	−0.8
Prof-2	4.1%	7.0%	2.9	3.7%	3.8%	0.1	2.4%	3.7%	1.3	2.7%	5.3%	2.6
Prof-3	0.7%	0.4%	−0.4	0.0%	0.6%	0.6	7.2%	12.2%	5.0	4.1%	3.3%	−0.7
Prof-4	10.5%	11.1%	0.6	8.1%	9.4%	1.3	23.7%	25.1%	1.4	24.3%	22.7%	−1.7

TP: type of profession, Prof-0: no-STEM professions, Prof-1: biosanitary, Prof-2: STEM without gender gap, Prof-3: digital content design and creation, Prof-4: STEM professions with gender gap. Dif: difference.

4. Discussion

The analysis of the results allows us to answer the research questions that were initially posed. Inspira STEAM improves the attitudes that young people have towards technology, their preferences for STEM-related professions, and female STEM referents named (RQ1). However, the improvement is very slight, almost nil, in mathematical self-efficacy, and no improvement in gender stereotypes were observed.

The girls showed lower mathematical self-efficacy and a worse attitude towards technology than the boys did (RQ2). This is in line with decades of widely spread studies, of questionable rigor, trying to show the biological differences in the brain among girls and boys [44], and studies that found that when girls demonstrated good mathematical performance, it did not correspond with their self-concept in math skills to the same extent as it did among boys [10]. Ashby Plant et al. [43] highlighted the importance of self-efficacy for achievement and motivation and indicated that interventions targeting self-efficacy can help young people achieve more and increase their interest in these areas. Regarding gender stereotypes, girls show fewer stereotypes than boys and list more female referents in science and technology, both those who are recognized and those from their environment.

In terms of career aspirations, the preference for non-STEM professions is more than 10% higher among girls than it is among boys (exceeding in all cases 70% of the choice among girls). The biosanitary option is also higher among girls. As expected, the choice of STEM professions with a gender gap is lower among girls, with a difference of more than 10 percentage points. These results confirm the various Spanish and international reports on university enrollment data [12,13].

The improvement in mathematical self-efficacy and gender stereotypes is slightly higher among girls, although, in both cases, it is very small and not significant (RQ3). Their beliefs about their capabilities and stereotypes are deeply rooted, and to reverse this situation, deeper work is needed that extends over time and that begins at an earlier age. The greatest increase among girls was in the item "Come what may, I am capable of handling it", which may be an indication of the empowerment that we perceived in the girls participating in the program. The impact of Inspira STEAM was greater among girls regarding their attitude towards technology, while there was hardly any improvement among boys.

As for female STEM referents, both girls and boys increased the percentage of women that they could name. The girls did so in favor of recognized women, while the boys could identify more close referents. Inspira STEAM positively influences the recognition of and feelings of ease and comfort with people involved in STEM around them, which has been shown to be more important than recognizing themselves in famous people when increasing STEM vocations [41]. The positive effect of role models has been seen in other studies using virtual role models [43], top women leaders from STEM companies [38], biographies of role models [33], and women with more experience in the close environment [42].

Finally, the program modifies the career aspirations of young people. Boys decreased their interest in non-STEM professions to a greater extent than girls did while increasing their interest in professions related to content design and production, STEM professions with a gender gap, and STEM professions without a gender gap, in that order. Girls reduced their interest in non-STEM professions, bio-health professions, and content production professions in favor of STEM-without-gap and STEM-with-gender-gap professions, in that order. These results demonstrate the need to raise awareness of STEM professions among young people so that they can aspire to them—professions that may be linked to their tastes and interests and that may not be related to science and technology a priori (i.e., gaming [7,8] and space exploration [6]).

During the socialization process, both inside and outside of the classroom, girls and boys internalize the stereotypical characteristics associated with their gender; these become part of their self-concept, of their own and others' expectations, of their aspirations, and of the skills they believe they have to adjust to social roles [25]. The literature shows that girls have the same mathematical skills and declares that they do not have gender stereotypes [36]. However, in Huguet and Régner's work, they warn us that we must be careful with these self-reported statements, as stereotypes may be implicit, and young people may not be aware that they affect them. Teachers agree in pointing out that stereotypes are not necessarily visible on the surface. This partially explains the results of our study. At all points where we measured stereotypes, girls are shown to have fewer stereotypes than are boys. However, an intervention such as Inspira STEAM does not achieve the goal of reducing gender-associated stereotypes. Neither the absence of gender differences in mathematics performance nor the counter-stereotypical beliefs of girls can be taken as sufficient evidence that stereotyping is not in operation.

Other aspects of the study may explain the lack of Inspira STEAM's impact on youth gender stereotypes. The measurement tool itself, which was designed in 2007, may not respond to the current characteristics of young people. There are items whose interpretation generates doubts for us, for example: "Women usually solve conflicts by using dialogue, by talking". Social desirability may also be an influential factor since it causes us to answer what is expected. In this sense, asking questions in the first person places a burden of responsibility and direct judgment on the respondent, which can be avoided by using the third person projective technique for questions such as "If a child wants to practice ballet, his environment would support him". This does not avoid social desirability, but it puts the focus on what others do and not oneself, so we can obtain answers closer to what really happens. Finally, it may be that the greater awareness developed during the program about gender stereotypes made young people more critical when responding to the questions. All of this leads us to consider the opportunity to develop a tool that measures gender stereotypes that is more closely linked to STEM areas and that overcomes obstacles related to social desirability and implicit stereotypes.

5. Limitations

Some of the limitations of this study derive from the selection of schools. Few schools volunteered to participate, which means that the sample is not as varied as we would like in terms of geographic location, socioeconomic level, or type of school. In addition, when the instruments were applied, many students did not adequately complete the data that would allow us to match the pre-test with the post-test. This led to us having to discard a significant number of responses. Finally, the fact that each group had different mentors means that there may be variables that we cannot control and that affected the results obtained even though the mentors received the same training and resources before conducting the sessions.

We warn of the difficulty of carrying out this type of study with elementary school students, so we recommend being very careful during data collection; carefully measuring the cognitive load necessary to apply the selected instruments (e.g., length, language, and context of application of the instruments) and in explaining the research methodology to teachers as well as supporting them with precise instructions and close monitoring at all stages. However, we also stress the need to rigorously evaluate the impact of these interventions in the classroom to draw conclusions, improve the intervention, and extrapolate the results to other proposals aimed at promoting scientific and technological vocations at these ages. Although there are studies that do not include these control groups [35], we consider it essential to design research that includes control groups to attribute the changes to the intervention carried out despite the logistical difficulties involved.

6. Future Work

This study opens future lines of research that we will address in subsequent studies. On the one hand, it is relevant to determine the differences between working in mixed groups and in separate groups according to gender. The experience and testimonies collected during five editions of this program from the girls and the mentors lead us to positively value the separate work in the sessions; however, this is a controversial aspect of the program that we would like to continue to deepen, and we wish to obtain more evidence to support this decision. As we discussed when analyzing the impact of this intervention on gender stereotypes, we could develop a tool that overcomes the limitations identified and that more effectively measures implicit stereotypes among elementary school students. Finally, it would be interesting to know the impact that Inspira STEAM has on the mentors who participate in the program.

7. Conclusions

To conclude, the students who participated in Inspira STEAM improved their attitudes towards technology, the number of female role-models they have in STEM-related areas, and their vocation to develop a profession linked to science or technology in the future. This impact was greater among girls. However, the gender stereotypes and the mathematical self-efficacy of the young people who participated were not altered. We saw that girls have worse attitudes towards technology, as seen in other studies [3], and mathematical self-efficacy, regardless of the group or time at which it was measured. Additionally, even when attitudes towards technology increased, they were still lower than the increases seen in boys.

Contact with female role models in science and technology has a positive impact and brings these professions and professionals closer to young people who often do not have the opportunity to meet these role models in their environment. It is everyone's responsibility to raise awareness and normalize the great contribution that women make to the fields of science and technology, and to show personal and professional diversity, so that girls can identify, become inspired, and take them as references. These role models can be well-known women with positions of leadership in prestigious companies; however, it is very important for girls to have role models in their environment so that they can feel closer and so that these role models are more accessible. On the other hand, the group mentoring methodology has proven to be appropriate for 6th grade students and could be adopted for other similar interventions. Girls need safe and trusting spaces where they can reflect so that they can share and express concerns about issues that affect them daily.

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