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Girls4STEM: Gender Diversity in STEM for a Sustainable Future

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Abstract: Science, Technology, Engineering, and Mathematics (STEM) are key disciplines towards tackling the challenges related to the Sustainable Development Goals. However, evidence shows that women are enrolling in these disciplines in a smaller percentage than men, especially in Engineering related fields. As stated by the United Nations Women section, increasing the number of women studying and working in STEM fields is fundamental towards achieving better solutions to the global challenges, since the potential for innovation is larger. In this paper, we present the Girls4STEM project, which started in 2019 at the Escola Tècnica Superior d'Enginyeria de la Universitat de València, Spain. This project works towards breaking the stereotypes linked to STEM fields, addressing both boys and girls aged from 6 to 18, but especially trying to open the range of career options for young girls through interaction with female STEM experts. The goal is to spark girls' interest in STEM disciplines from childhood, so that they become more self-confident in these areas. To achieve this goal, the project is built over three main actions: the Girls4STEM Family Talks, where students, families, and teachers participate; the Girls4STEM Professional Talks, where the target is a general audience; and the Initial Training Seminars for teachers. Short-term results are here presented, showing that aspects related to self-perception and perception from others (family, teachers) play a significant role. Moreover, these results also indicate that there may not be a general understanding of which disciplines are included in STEM.

Keywords: STEM; ICT; gender diversity; self-efficacy in STEM

1. Introduction

STEM is a widely used acronym for the fields of Science, Technology, Engineering, and Mathematics. According to Sanders [1], the National Science Foundation (NSF) in the United States in the 1990s realized that the shortage of students enrolled in STEM disciplines would have major consequences such as a poorly prepared workforce to face the challenges of economic and industrial development at a time of great international competitiveness. Some years later, the Rocard report

in 2007 [2] warned again about the lack of promotion among students in Europe of scientific and technological vocations that the labor market was demanding in STEM areas, as well as the gender and socioeconomic bias existing in the access to these vocations.

Predictions indicate that STEM, especially Engineering and Technologies such as the Internet of Things, Big Data, or Artificial Intelligence, are profoundly transforming our society and the labor market. This social change will require the training of students prepared to learn and develop 21st century skills such as communication, critical thinking, creativity, and collaboration, to effectively join the labor and social world, where they will have to solve problems in a global and changing environment [3]. Furthermore, it is expected that half of the jobs that currently exist will have disappeared by the year 2050. The 65% of children beginning elementary school today could develop a career in jobs that do not currently exist yet, as it is stated in The Future of Jobs Report [4]. These global challenges can become opportunities to educate children as future citizens acting as agents of change in policies that enable a more sustainable future [5] in terms of equity, inclusion, diversity, prosperity, and justice, key aspects included in the Sustainable Development Goals (SDGs). The SDGs [6] were approved by the United Nations General Assembly in 2015 within the 2030 Agenda for Sustainable Development and are based on five areas such as People, Planet, Prosperity, Peace, and Partnership [7]. There are 17 SDGs and 169 targets divided into a total of 246 indicators that are used to measure the progression in achieving the relevant goals [8].

It is important to note that the notion of sustainability has gone beyond environmental considerations, including social and economic dimensions [9]. Nowadays, the different dimensions of sustainability overlap and, as an example, it is not possible to have sustainability without social sustainability [10]. On the one hand, psychologically, sustainability is viewed also in terms of promoting the well-being of all people in terms of enrichment, growth, and flexible change [11]. On the other hand, gender equity and diversity is a question of matter in the promotion of social sustainability from the perspective of education, in order to create awareness of gender stereotypes and promote long-term changes in attitudes in school-age children and their communities. According to [12], gender-based attitudes are socially constructed and learned through all kinds of educational institutions: formal (such as schools and universities), non-formal (such as families and workplaces) and informal (such as social relationships, and recreational activities).

In this framework, we present in this paper the Girls4STEM project that started in 2019 at the Escola Tècnica Superior d'Enginyeria de la Universitat de València (ETSE-UV), Spain, addressed to the promotion of SDG4 (ensure inclusive and equitable quality education and promote lifelong learning opportunities for all) and SDG5 (achieve gender equality and empower all women and girls) through the organization of dissemination activities where students aged from 6 to 18, their families, teachers, and STEM professional women are involved. In particular, this project aims to contribute to the SDGs achievement working on gender diversity and equality and demonstrating that STEM disciplines suppose an improvement to the common good of society, as well as showing the influence of Engineering and Information and Communication Technology (ICT) in the SDGs. The project works to change common ideas and beliefs linked to STEM fields, where the lack of female professionals greatly reduces the diversity of perspectives and the ability to offer different answers and breadth to new problems. The goal of the project is closely related to sustainability through the creation of sustainable communities without gender-based disparities and the SDGs achievement, where 104 of the 246 indicators distributed across 9 of the 17 SDGs are identified as gender-related [8,13]. Following the definitions in [11], Girls4STEM can be regarded as a sustainable project, since it tries to change the current under-representation of women in STEM areas in order to achieve better solutions to the global challenges stated by the SDGs. As clearly indicated by [13–15], gender equality is fundamental to achieve the 2030 Agenda. The inclusion of the gender perspective into the implementation of all SDGs is therefore crucial.

The main contributions of this paper are the following:

- The project Girls4STEM is presented as a useful initiative towards breaking stereotypes and opening the range of career options, especially for women.
- The programmatic theory of change underlying the project is stated, and the project implementation is carefully described to allow interested institutions adopting similar strategies. In addition, recommendations for ensuring a sustainable implementation are provided.
- Exploratory short-term results are given to support the project, linking them to fundamental concepts related to STEM such as self-efficacy and self-perception.

The remainder of the paper is organized as follows. Section 2 describes the motivation of the project and its specific objectives, while Section 3 presents the implementation and the main functional blocks of the project. Evaluation of the project is discussed in Section 4, and short-term results are given in Section 5. Finally, conclusions are drawn in Section 6.

2. The Girls4STEM Project

2.1. Background and Motivation

There is a growing gap between men's and women's participation in the digital sector, as stated for example by the European Commission in their 2018 report [16]. The number of women interested in participating in the sector, including education, career, or entrepreneurship, has suffered a setback. Closing the digital gender gap in STEM and ICT is not just a matter of social justice, it goes beyond ensuring equal opportunities for men and women, which is a right guaranteed by European legislation. It is also an economic issue. According to the aforementioned report, European economy productivity loses more than 16 billion euros per year due to women leaving their digital jobs.

The economic benefits of gender equality have been also deeply analyzed by the European Institute for Gender Equality in [17]. This study develops a model to estimate a wide range of macroeconomic benefits of gender equality at the European level. This model states that improving gender equality would have a very positive effect on Gross Domestic Product (GDP) and on women's employment. As an example, they forecast that, by 2050, improving gender equality would lead to an increase in the European GDP per capita from 6.1 to 9.6 (equivalent to €1.95–3.15 trillion) and would also steer towards the creation of 10.5 million jobs by 2050 (for both men and women).

The gender gap, and in particular the STEM gender gap, will not close by itself, since it is not a matter of time. It is essential that governments, institutions, and companies take actions to revert this situation. The European Union started several years ago to take steps to close this gap. The Helsinki Group and the European Commission in consultation with the European Research Area stakeholders developed a guide to promote gender equality in research and innovation [18]. The European Commission presented in 2020 the Gender Equality Strategy 2020–2025 [19], which includes policy objectives and actions towards a gender-equal Europe.

Following these directions, in Spain, since March 2019, a new state law (Real Decreto 6/2019 [20]) requires companies with more than 50 workers, including both public and private universities, to have an Equality Plan that seeks effective equality between men and women. There is a significant increase of research organizations which among their policies include gender equality plans. In 2013, in the European Union, 36% of the organizations performing research adopted gender equality plans [21]. This amount increased to 55.9% in 2016 [22]. These plans include measures related to recruitment and promotion, flexible career trajectories, or support for leadership development.

In line with what is being done by European institutions, Spanish universities have considered intervening to close the STEM gender gap. Through the equality plans and diagnostic studies prior to their preparation, they warn and point out that both the horizontal and vertical segregation suffered by the academic institutions, as well as the loss of women's talent, is a structural issue that has a diversity of causes and problems. Therefore, it has to be addressed from a gender perspective.

Since 2011, the ETSE-UV, as a higher education institution, has been implementing a pilot program, which defines three basic lines of action [23,24]:

1. To disseminate the social applicability of studies and professions in STEM areas, with special emphasis on the fact that Engineering and Technology could also contribute to the common good of society. Based on stereotypes, girls often choose care-related vocations, so it is important for them to know that STEM disciplines are essential when it comes to generating changes in society.
2. To promote the creation of support networks, through mentoring programs among girls.
3. To increase the visibility of STEM female role models of proximity. It is essential that both girls and boys know the women scientists who have changed the history of science, but these references will not make them feel more motivated when choosing these studies. They need to know much closer references in which they can see themselves identified. Normal women with an interesting day-to-day job activities.

This pilot program has allowed the ETSE-UV to increase the number of women enrolled in STEM-ICT degrees above the national average [23,25]. However, although actions at the university level are important, girls begin to show a lack of confidence in their abilities for STEM disciplines before they turn six years old [26]. For this reason, it is essential to involve non-university educational institutions in the process. UNESCO published in 2017 a report [27] analyzing the causes of the STEM gender gap and compiling evidence and possible lines of action. In this sense, increasing the positive STEM referents that girls and boys receive is crucial. However, in the case of girls, the disclosure of the benefits of working professionally in one of these areas is not enough since, as indicated by UNESCO [27], for girls to feel identified it is necessary that they see female models and references, so they can "imagine" themselves in their adult life [28].

2.2. Lines of Action

Higher education institutions can and must play an important role in transforming this reality. From their position, as a link between the world of pre-university education and the labor market, they are the key to carrying out a dissemination of the social applicability of STEM, highlighting the final link between the disciplines and society. Thus, on the premises that educational institutions can develop a significant role in three dimensions: (i) act from an early age; (ii) show the day-to-day work in STEM areas; and (iii) use female referents, Girls4STEM is born. The project is based on the following theory of change [29]:

If institutions of higher education, together with critically important stakeholders (i.e., families, teachers, STEM professionals, regional education entities), can collaborate and promote the visibility and relevance of STEM contributions, targeting students from six years old, then common ideas, beliefs, and stereotypes linked to STEM fields can be challenged and, hence, STEM vocations can be raised.

Girls4STEM is a project from the Universitat de València that belongs to the strategic lines of its 3rd Equality Plan and it is linked to the Vice-Principal of Equality, Diversity and Sustainability. The Girls4STEM project has been conceived as an extension of the ETSE-UV's pilot program, covering and extending the activities that started in 2011. Basically, the main difference is the extension of the targeted audience by covering a broader range of pre-university ages (from 6 to 18 years old), as well as their environment (family, teachers, and regional education entities). It should be noted that the project does not replace the ETSE-UV working program [23] but is linked to it. In fact, ETSE-UV students are encouraged to collaborate in the Girls4STEM project in order to act as STEM role models during the Girls4STEM activities.

The main objective of the project is the promotion of vocations in the STEM areas and, in a very particular way, among the girls, thus trying to reverse the female under-representation in these disciplines by challenging common stereotypes. Girls4STEM targets the following specific objectives:

1. Promote STEM vocations.
2. Arouse curiosity about STEM from an early age.
3. Encourage the active participation of several agents: students, families, teachers, regional education entities, STEM experts, companies, and the Universitat de València.

4. Increase the visibility of scientific STEM advances and connect them to their social value.
5. Increase the visibility of female STEM researchers/professionals and their professional contributions.

In this way, Girls4STEM is designed to articulate the participation of all the agents involved in the promotion of STEM vocations, with the ETSE-UV remaining as the central node coordinating their interaction. The project planning is led by the ETSE-UV, and includes the collaboration of regional education entities and companies that were supporting the project. The participation of the regional education entity in charge of the pre-university teachers training, whose original name in the Valencian Region is *Centre de Formació, Innovació i Recursos per al professorat* (CEFIRE), has been fundamental towards reaching primary and secondary schools and engaging them in the project. Note that the families are reached via the interaction with the participating schools and students. In the planning stage, the hidden assumption was that there would be interest in the activity from the main agents, that is, the schools, the students, and their families. To help overcome this possible lack of interest, two rewards related to the fulfillment of the project's activities were defined both for the teachers and the participating students (see Section 3).

The project's cornerstone is the interaction between female role models and the participating pre-university students, which is mostly held in informal learning environments. The actions proposed within the project are focused on showing the students what a STEM profession involves, via the female role models which are referred to as "STEM experts". Note that, from this point, when referring to a STEM expert, a female STEM expert is implicitly assumed. In addition, the project has been designed to position the girls and boys as active participants through the proposed activities, thus increasing personal confidence and, consequently, reducing their fear of choosing STEM studies. References and evidence described in [28,30–38] are at the core of this design. More specifically, the interaction with the STEM experts can be regarded as a vicarious experience [33], promoting STEM self-efficacy, while informal learning environments are seminal towards developing interest in STEM [34,35]. The project actions also include "public speech" events, performed by the STEM experts. This strategy helps with regaining the presence of women [36,37], and, as stated in [38], there is an impact over: (i) the self-efficacy through the interaction with STEM professionals (promoting STEM vocations); (ii) the perception of STEM disciplines as a means to achieve a communal goal, allowing for giving visibility to STEM role models (increasing the impact on students who did not believe STEM to be an option for them in the first place); and (iii) the opportunities to provide professional orientation.

Considering the specific objectives detailed above and the strategies defined in the project planning stage, the main actions requiring the STEM expert participation are the Girls4STEM Family and the Girls4STEM Professional talks. On the one hand, the Girls4STEM Family Talk is aimed at pre-university students to get to know the day-to-day of a STEM expert. Students, aged 6 to 18 years old, meet the STEM expert, and, after an interaction with her, a video of her professional life is recorded. These videos are presented in the Girls4STEM Family Talk held on a Saturday morning as part of the family leisure activity. On the other hand, the Girls4STEM Professional talks try to bring STEM disciplines closer to the general public, in order to promote the understanding of scientific and innovation-related concepts. This set of public events consists of several "public speeches", given by the STEM experts that collaborate in the project. In the following section, the project implementation is described, and guidelines for ensuring its sustainability over time (intermediate and long-term) are provided.

3. Project Implementation and Sustainability

In order to accomplish the goals of the project, three actions are planned depending on the target audience: Girls4STEM Family Talks, Girls4STEM Professional Talks, and the Initial Training Seminars. The main steps of the project implementation are shown in Figure 1, where the participating agents are represented by the "Project roles". A detailed explanation of each of these steps follows.

Girls4STEM Family Talk: This activity is aimed at pre-university students (primary/secondary). The main objective is to learn about the daily life of a professional STEM woman, what her work consists of, and the personal and professional advantages of being a STEM woman. The purpose is that students can build STEM referents, and to arouse curiosity about these types of jobs that are often unknown by most of the students, even by society in general. The process is as follows:

- The STEM expert signs up via the registration form in the Girls4STEM web page, indicating her specific STEM area and a short bio (Figure 1 (3)). The expert selects her kind of participation in the project: Family Talk activity, Professional Talk activity or both. This information is public and the School Center uses it to choose the experts they would like to interact with. The participation is voluntary and any STEM expert can join the project. Up to now (June 2020), 100 STEM experts have registered in this initiative.
- The School Center signs up via a registration form in the Girls4STEM web page (Figure 1 (1)). The Organization Team proposes five Family talks during the academic year, considering that this number is a good balance between the effort of the Organization Team and the impact of the project in the long-term. Two School Centers are scheduled per Family Talk to limit the duration of the session to one hour maximum. The School Center selects the Family Talk date among those available. The Organization also maintains a waiting list for the next editions. In the first edition, 10 schools have already participated, and 10 School Centers are on the waiting list for next editions.
- The Organization Team assigns the experts to the School Center from its preference list, also being in charge of initiating the contact between the center and the experts (Figure 1 (2)).
- The STEM expert meets the students at their School Center, at her workplace or by a video-conference (Figure 1 (4)). In this meeting, the students interview her and talk about her professional career, what a STEM job consists of, how her daily life is, the reasons that led her to choose a degree in the STEM field, the advantages and possibilities of a career in this area, the obstacles she faced, etc. The students make a three-minute video long based on this information (Figure 1 (5)). Note that the duration of the video needs to be kept short to ensure the engagement of the target audience. In the first edition, 40 female STEM experts have already met more than 400 pre-university students.
- The video is presented in the Girls4STEM Family Talk (Figure 1 (8)). These talks are held on a Saturday morning at the http://www.jardibotanic.org/?idioma=_eng Jardí Botànic of the Universitat de València, in a natural and playful environment. Students with their families and friends, teachers, and STEM experts attend the event. Two School Centers participate in each session, presenting a maximum of eight videos per talk. Note that the project limits to 4 the number of STEM experts that a School Center can interact with. Experts, students, teachers, and families share their experiences and how their perception about STEM branches have evolved in the recent years. In addition, the STEM experts can give some tips to families to spark interest in STEM disciplines. In this leisure environment, typical Valencian snacks and soft drinks are offered, and other gift items courtesy of the sponsoring companies. The Organization Team uploads the videos to the https://www.youtube.com/channel/UCz-Ie0ykkPIhxzKhNkOwfwg/featured Girl4STEM YouTube channel to make the biographies of the STEM experts visible and reach a wider audience. In this first edition, five Girls4STEM Family talks have been scheduled between January and June 2020.
- Once the activities are fulfilled, the School Center receives a reward in the form of a 3D-printer (equivalent to four videos) or a tablet per video (up to three videos), which contributes to increasing the motivation of students and teachers.

Girls4STEM Professional Talk: This activity is aimed at teachers, secondary school students and general public over the age of 16. The main objective is to present the project to the teaching staff, a

key piece to promoting participation of pre-university students. These talks seek to show the most human and least known side of professions in the STEM field. The process is as follows:

- The STEM expert signs up via the registration form in the Girls4STEM web page, indicating her specific STEM area and a short bio (Figure 1 (3)). The expert selects her kind of participation in the project: Family Talk activity, Professional Talk activity, or both.
- The Organization Team selects four invited speakers from different STEM disciplines for each talk in order to cover a wide range of STEM professions (Figure 1 (6)). Each expert is recommended to prepare a 10-minute maximum talk to ensure the dynamism of the activity. This variety of STEM disciplines serves as an inspiration to the teachers to transmit the interest about the STEM disciplines among their students.
- Sessions of the Professional Talks are held on Thursday evenings (Figure 1 (9)), as an alternative leisure plan, in emblematic buildings of the Universitat de València, helping to enhance its relationship with the Valencian society and making its history known. In the talks, soft drinks and/or water and a snack are offered to those attending, courtesy of the project's sponsoring companies.

Initial Training Seminar: The third action is a training activity designed for pre-university teachers (Figure 1 (7)). It is a two-hour session to explain the objectives of the project and to provide the teaching staff with a guide of best practices. The teachers attend this seminar before starting the project with the students. The Organization Team offers two different dates during the scholar academic year.

The participation of the teaching staff is certified by the official institution in charge of the pre-university teachers training (Figure 1 (10)), that is, CEFIRE in our case. This activity is recognized as a practical training equivalent to a total of 30 training hours, allowing for increasing the interest of School Centers in the project, as discussed in Section 2.2. The teachers enrolled in the Girls4STEM program are required to: (i) attend an Initial Training seminar; (ii) attend at least one Professional Talk; and (iii) guide a group of students in the elaboration of the video to present in one of the Family sessions that they also attend.

The sustainability of a project of this type is one of the key aspects to cover when long-term results are aimed at for a project. In this sense, the Organization Team has designed several strategies in order to guarantee the continuity of the project over time. These strategies are focused on the different agents that participate:

- The certification of the participation of the pre-university teachers by the CEFIRE is highly valued for teacher academic recognition and future promotion. These kinds of initiatives are included in the primary and secondary academic curriculum so that the interest of the School Centers is also guaranteed. This fact makes the initiative a remarkably rewarding and fulfilling experience for both sides, School Center and teacher staff.
- A STEM expert's participation is voluntary and non-economically remunerated. In order to assure the project's continuity, the objective is to enlarge the STEM expert database as much as possible to minimize the effort of the STEM experts. In this sense, continuous dissemination of the project activities and achievements via social networks is fundamental, supported also by the companies collaborating on the project, as well as the professional entities.
- This program relies heavily on the commitment of the Organization Team that is mainly composed of faculty members. Figure 2a) shows the breakdown of the project participants depending on the group they belong to. Note that this type of extra-curricular work does not have a real impact on the career of the Team members (i.e., Organization Team and University Collaborators), which is evaluated on the basis of contributions in research and teaching, fundamentally. However, the positive feedback obtained from the School Centers, students, STEM experts, and teachers motivates the Team members. Note also that this type of project can be regarded as a transfer of knowledge to society, being a very valuable contribution. To decrease the time investment on the

project's actions, shifts have been arranged among the Team members, so they are only required to provide support for a limited set of actions. In this first edition, the Organization Team has made a great effort to design and define the administrative protocols in order to easily externalize the management work in future editions, while the decision-making tasks would remain within the Organization Team. Note that this collection of protocols and management tools is also a short-term milestone of our project.

- In order to offer proximity STEM referents to pre-university students, ETSE-UV's students collaborate in the development of the different actions. The University grants them with a 2 European Credit Transfer and Accumulation System (ECTS) that can be included in their student record. Although both female and male students can participate, female students are especially encouraged.
- The annual economic cost of the project is about €32,000. This amount is financed both through public and private funds, as shown in Figure 2b. Public funding comes both from the University itself and from projects and agreements signed with the public administration (Spanish and Valencian Regional Government, respectively). Private funds during the first year were obtained in the form of items such as the website implementation and maintenance, payment of conference rooms, etc. However, the project has received an accreditation for patronage http://mecenatge.gva.es/es/projectes-i-activitats-cientifiques-d-interes-social-a-la-nostra-comunitat/-/asset_publisher/172tMyBqeWmq/content/universitat-de-valencia-girls4stem, and it is expected to receive funds from companies via their Corporate Social Responsibility (CSR).

The information about the project is available on the project website http://girls4stem.es and is spread through social media profiles in Facebook http://www.facebook.com/Girls4STEM, Twitter https://www.twitter.com/Girls4STEMVLC and Instagram https://www.instagram.com/girls4stemvlc.

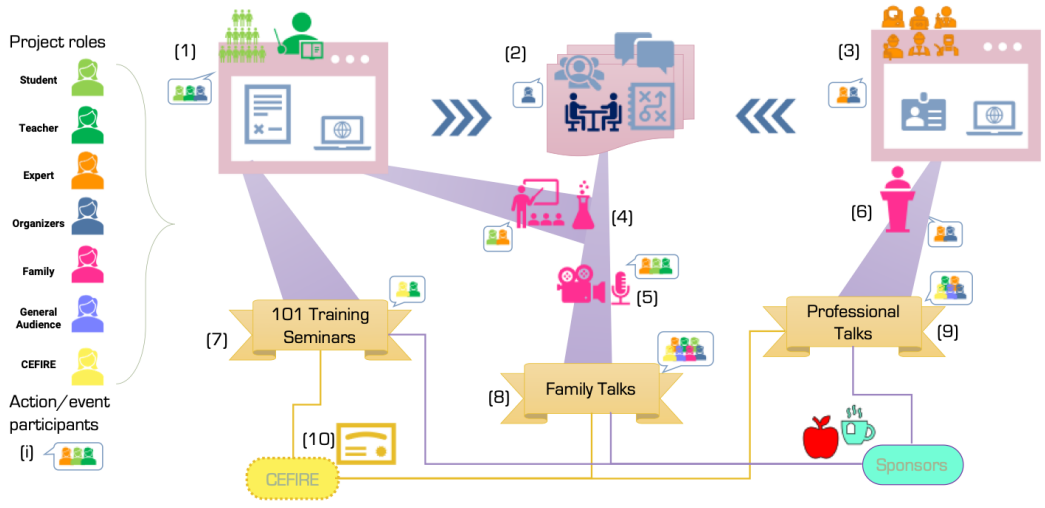
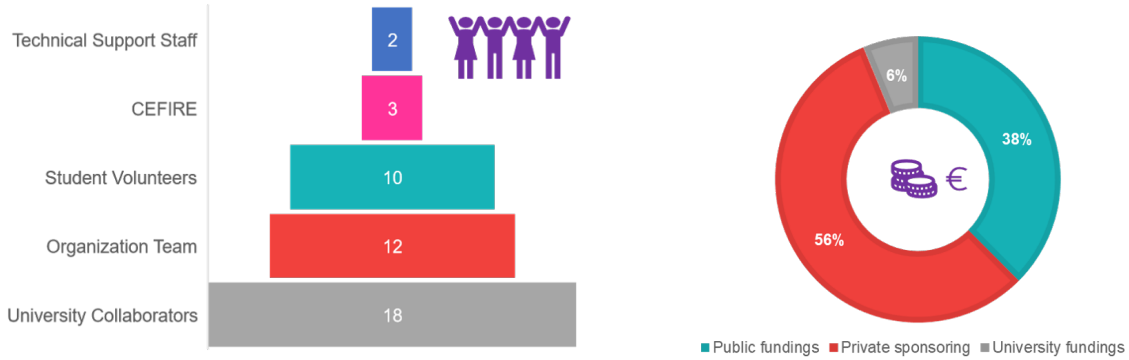


Figure 1. Main activities and roles in Girls4STEM project implementation: (1) School Center; (2) Matching between STEM expert and School Center; (3) STEM experts; (4) Students-Expert meeting; (5) Video creation; (6) Expert selection for Professional Talk; (7) Training Seminar; (8) Family Talk; (9) Professional Talk; and (10) CEFIRE entity.



(**a**) (**b**)

Figure 2. (**a**) project breakdown: number of people per group. (**b**) financial sources (percentages).

4. Evaluation

The evaluation of a project of this kind is not straightforward and it is difficult to establish a set of objective metrics and indicators (see, for example, [39], which states the need to find efficient methods to achieve evidenced-based interventions from research in the field). Reviewing the literature related to promoting STEM vocations, self-efficacy is one of the key concepts [30,32]. In fact, its impact has been analyzed in several dimensions, ranging from the connection between aspirations and career choices to the persistence in the STEM field. Seminal references such as [27,30] point out that efforts must target expectations and social practices in several influence spheres, including family, school/faculty, media and workplace/employers aiming to tackle variables decreasing the personal efficacy as well as building institutional barriers. It is not a matter of forcing women entering STEM fields. The main purpose is to leverage sex stereotypes and therefore to enable women to experience, and open the range of career options for them [30].

Taking into account the above considerations, the recommendations given in [38] were taken as a basis in the planning stage. Document [38] provides a methodology towards defining objective indicators, as well as describing how to collect the data and build the different variables. Following the theory of change stated in Section 2.2, evaluation tools and milestones have been defined in three time scales: short-term, intermediate, and long-term. Short-term milestones included the definition and implementation of an efficient project management task breakdown and tools, as explained in Section 3. This section presents the short-term evaluation tools, which have been used to obtain useful feedback towards achieving intermediate and long-term goals, discussed in the next section.

To evaluate the short-term impact in a qualitative way, different questionnaires have been designed, covering the entire target audience of the project: pre-university teachers, primary and secondary students, and their families. Pre and post questionnaires for the different actions, Family and Professional Talks, have been planned. With the aim of increasing motivation during the Family and Professional Talks and collecting data in a fun way, online tools that incorporate audience response capabilities have been used [40,41]. Among the most popular participation management tools, *Kahoot!* https://kahoot.it has been chosen. In the following paragraph, the surveys are explained in detail:

- **Girls4STEM Family Talk:** Questionnaires have been designed for four surveys, two of them for the students (pre-survey and post-survey), and the other two for the Family Talk attendees (pre-survey and post-survey).
  - The students carry out two surveys: one before starting the interaction with the STEM experts (at the School Center) and the other as a final task at the Family Talk, after the presentation of the video. The idea of the pre-survey is to determine the knowledge that students have about the gender perspective in STEM disciplines, in order to evaluate the influence of this type of

initiative through a post-survey. These surveys are carried out by the students with online questionnaires.

- The pre-survey for the Family Talk attendees has been performed through the registration form by including a set of basic questions related to STEM general knowledge, since the perception of the family and teachers is fundamental (see Figure 3 questions Q1, Q2.a, and Q2.b) Although Figure 3 shows the pre-survey and post-survey for attendees at a Professional Talk, the same questionnaire applies to the pre-survey and post-survey Family Talk attendees.. The post-survey has been designed in a contest format through *Kahoot!* that allows for measuring the interest of the activity. It is launched at the end of the Family Talk, in a relaxed atmosphere. This post-survey includes questions about the presented videos, STEM general knowledge, and opinion questions about the dynamic of the session (see Figure 3 questions Q3, Q4, Q5, and Q6).

- **Girls4STEM Professional Talk:** In this action, questionnaires have been designed for two surveys for the Professional Talk attendees.

  - The pre-survey for the Professional Talk attendees has been performed through a registration form including a set of basic questions related to the knowledge of STEM disciplines (see Figure 3 questions Q1, Q2.a, and Q2.b). It is worth mentioning that the audience includes teachers, students over 16, and professionals in general.
  - The post-survey for attendees has been carried out in contest format through *Kahoot!*. This questionnaire is launched before ending the session, and it includes questions about the STEM expert's talks and the knowledge of STEM disciplines. It also gathers opinions about the dynamic of the session (see Figure 3 questions Q3, Q4, Q5, and Q6).

In the next section, short-term results are presented after applying the evaluation tools stated above. First, the project is characterized according to the number of attendees in the different activities and its impact on social networks. Second, we analyze how the project is viewed by its audience. Aspects related to a priori knowledge about STEM are evaluated and compared with a posteriori results. Finally, the impact of stereotypes and the students' self-perception and their perception from others are assessed, showing important differences by gender.

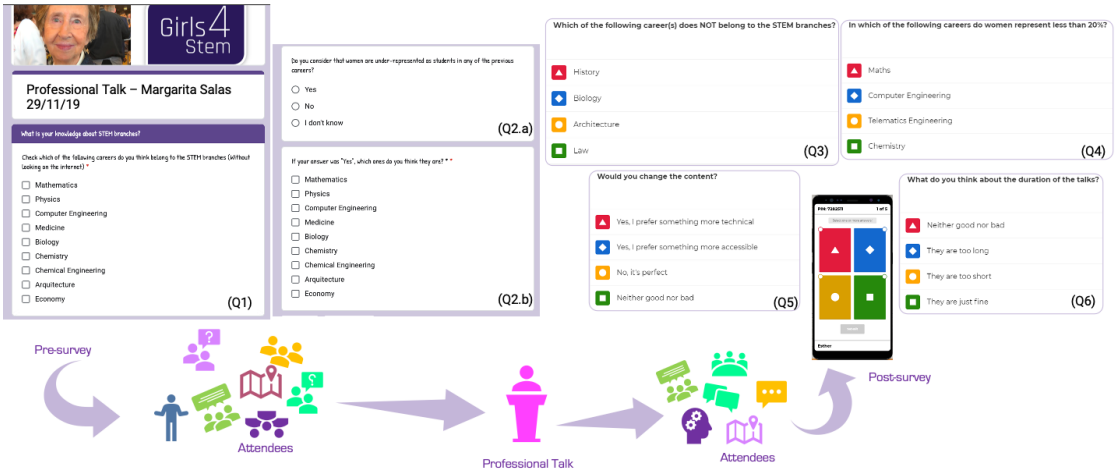


Figure 3. Sample of questions in the questionnaire of the pre-survey (Q1, Q2.a, Q2.b) and post-survey (Q3, Q4, Q5, Q6) for attendees at the Professional Talk.

5. Results

In order to measure the impact of Girls4STEM, we first characterize the project by its numbers. In this sense, and as mentioned in Section 3, the maximum possible number of centers registered

for the Girls4STEM program was achieved. This is 10 schools involving more than 400 students. In particular, 75 students from primary (17%), 311 from secondary (first and second cycle) (71%), and 9 from professional studies (2%), with 56.7% of them being women (see Figure 4). Note that the secondary school level is the one presenting a more balanced participation in terms of gender. The imbalance in the primary school level is due to the fact that only two primary schools participated in this first edition.

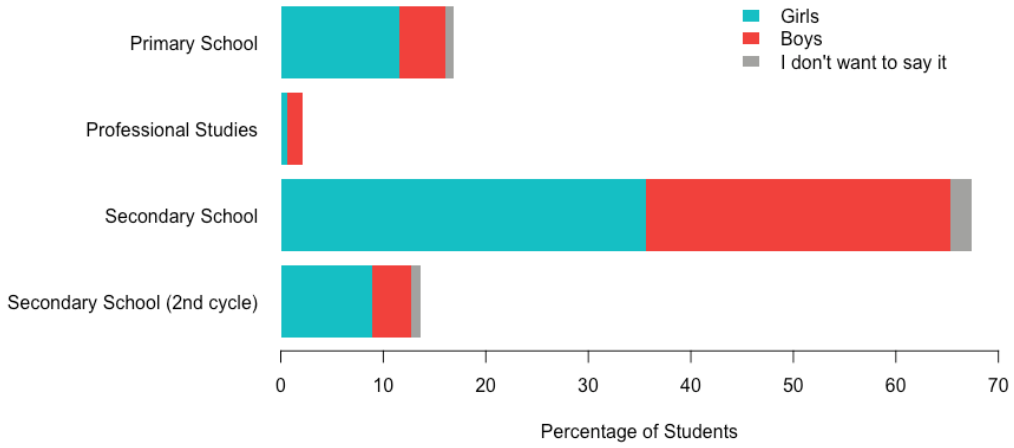


Figure 4. Percentage of students enrolled in the project by educational level and gender.

The Professional Talks were attended by a total of 414 people, 56% of them being women. Interestingly, around 33% of the attendees were professionally related with education. Despite being attended by a large audience which included whole families, the system only registered 329 people. Regarding the Initial Training Seminar, 40 people attended the session, 87% of them being women. Moreover, 83% of the audience were secondary teachers.

Another important indicator of the number of people that the project reaches is the number of followers in its different social networks (all under the user @Girls4STEMVLC). In particular, Girls4STEM has a total of 1267 followers on Twitter, 400 on Instagram, and 190 on Facebook (numbers according to June 2020).

Secondly, from the project's evaluation point of view, it is important to assess the perception that the attendees had, both about the project itself and about the need of improving women under-representation in STEM areas, i.e., were they aware of this under-representation in a first place? Regarding the organization of the events, 75% of the audience (aggregating Professional and Family Talks) showed a very positive response about the format and the duration of the talks and 16% just mentioned some aspects which could be improved. These aspects included shortening the duration or changing the level of specialization of the talks (some pointing towards more and some towards less specialized topics, so these answers can be regarded as showing variability in the perception). This information is collected via the *Kahoot* questionnaire at the end of the Family and Professional Talk (see Figure 3, questions Q5 and Q6 of the post-survey for attendees.)

With respect to the previous awareness that the audience of Professional and Family Talks had about STEM disciplines and, in particular, about the lack of gender diversity in them, around 80% of the audience pointed out that women were under-represented in STEM degrees (meaning that the percentage of enrolled women was below 20%) and related this under-representation mostly with Software Engineering (55.34% of the audience), Mathematics (53.62% of the audience), and Physics (45.75% of the audience) (see Figure 5). The data were collected from the registration forms of the Family and Professional Talks (see Figure 3, questions Q1 and Q2 in the pre-survey for attendees). It should be highlighted that, while the under-representation is true for Software Engineering (less than 15% of the students), and for Physics (around 25%), it is not so for Mathematics where women have historically represented almost 55% of the students although it has been decreasing lately arriving

to 40% in 2019. Note that these numbers are extracted from the Spanish Secretary of Universities [42]. It also worth mentioning that 22.5% of the audience considered Economy as a STEM career, indicating a lack of knowledge about what STEM really means. This result proves that, as stated in [38], there is an opportunity for providing professional orientation in projects such as Girls4STEM. Finally, we compare these previous results from the registration forms (see Figure 3 questions Q1 and Q2 of the pre-surveys for attendees) with the posterior results after attending the Professional and Family Talks (see Figure 3 questions Q3 and Q4 of the post-surveys for attendees). In this case, the *Kahoot!* game included a similar but simpler questionnaire, and 70% of the audience was able to correctly distinguish between STEM and Non-STEM careers and to adequately point out the disciplines suffering from the lack of gender diversity.

In a third place, we assessed the impact of stereotypes and the dimension of self-efficacy and self-perception. The students enrolled in the project answered a questionnaire before interacting with the STEM experts that measured their perception about the professional careers of women (see Figure 6 questions Q1, Q2, Q3, and Q4 of the pre-survey for students). In this sense, they were shown a photo of a man and a photo of a woman in similar scenarios and needed to answer which of them had a given employment. The results (see Figure 7) show no significant differences among the proportion of students who chose the woman photo versus the man photo. This fact could also be explained because most of the School Centers registered in the project were motivated and they had already performed prior gender-sensitive activities (6 out of 10 centers). It is worth looking at the answers of primary school students (dark red and dark turquoise) where the gender roles of our society are clearly reproduced. However, despite not showing differences in the external perception of who can do what, when it turned to their self-perception, a significant difference was observed.

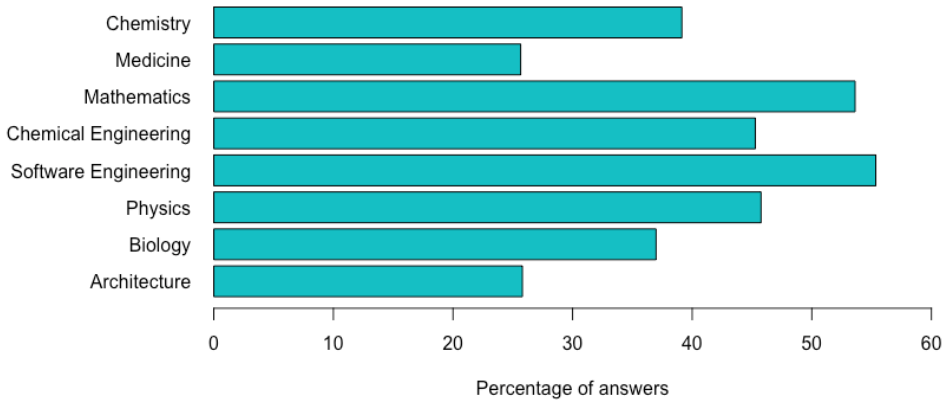


Figure 5. Percentage of the audience that considered women to be under-represented in each discipline.

The students were asked to point out subjects where they performed at a high level, as well as to indicate the perception of their teachers and parents (in the pre-survey for students). Figure 8 shows the percentages obtained for each one of the subjects, related to the Spanish curriculum. It should be highlighted how girls seem to be more self-confident about their performance in Languages and Natural Sciences, while boys do so in Physical Education, Mathematics, and Geography. In particular, only 35% of the girls mentioned Mathematics as one of the subjects they outperform, while this percentage increased to 50% for boys. However, regarding what they consider their teachers perceive, the percentage of girls who mentioned Mathematics increased to 43% while the percentage of boys remained constant. This result is consistent with the evidence that indicates that women usually have a low self-perception of their ability to do maths [27]. In any case, the results indicate that the family perception seems to be better than teacher and self-perception, in most of the subjects. It is worth mentioning the high perception that boys seem to have about their performance in Physical Education. This perception may be explained by societal gender roles imposing higher standards for men's physical condition.

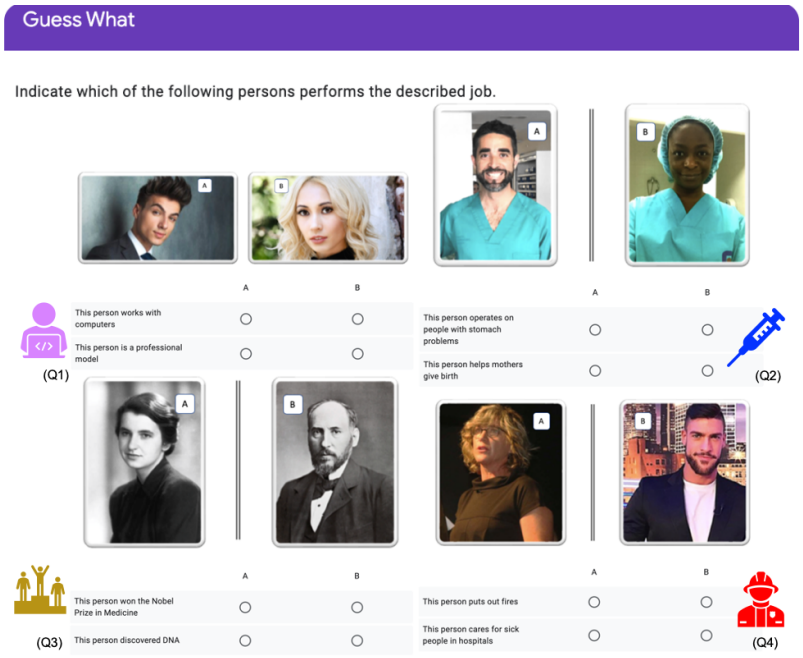


Figure 6. Examples of questions in the questionnaire of the pre-survey for students related to stereotypes.

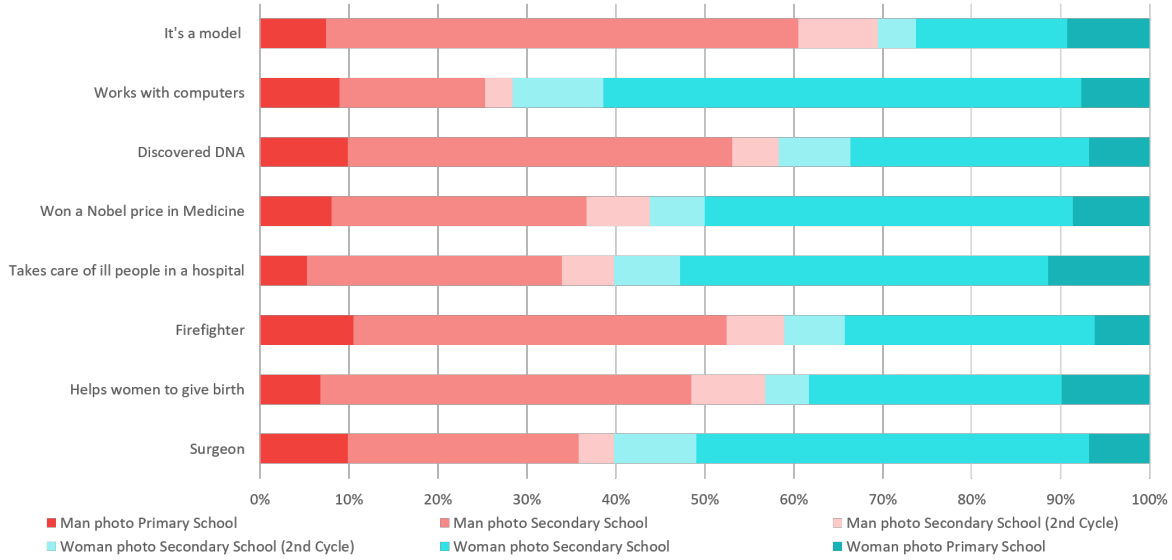


Figure 7. Percentage of students which chose the man photo (reddish colors) or the woman photo (turquoise colors) for each employment.

The short-term results obtained in the first edition of the project support that efforts towards breaking stereotypes related to STEM careers and studies should start by disseminating and clarifying which disciplines are included in STEM. Assessment of prior prejudices and perceived self-efficacy is mandatory, since these indicators have been directly related to persistence in STEM [32,33]. In the intermediate time-scale, the main milestone is to ensure the continuity of the project over time, following the recommendations given in Section 3. Regarding the intermediate results, the feedback obtained in this first edition has been used to modify the pre and post questionnaires of each action, in order to achieve a tool with higher capabilities of assessing perceived stereotypes and self-efficacy in STEM-related subjects, as well as profiling the attendees of each action. With these enhanced tools, it will be possible to longitudinally keep track of whether the project is achieving an increased (or

at least sustained) knowledge about STEM and their social value, as well as about the contributions of STEM professionals. A secondary intermediate milestone will be the tracking of the number of applications from School Centers, and an assessment of the interactions over social networks that will help evaluating whether both the interest in the project and the visibility of STEM remain.

As future work towards the long-term goal, promoting STEM vocations, the project will keep track of the percentage of female students registered in STEM studies at the Universitat de València, with special focus on the first-year enrolled students, instead of on the accumulated number.

Figure 8. Percentage of students that mentioned their out-performance in a given subject according to their self-perception (bottom row), their teachers perception (middle row) and family perception (top row).

6. Conclusions

In this paper, the Girls4STEM initiative, which started in 2019, is presented. The main goal of the project is breaking the stereotypes linked to STEM fields, opening the doors to more students, especially girls, to STEM disciplines. To this end, girls and boys from 6 to 18 years old, as well as their family and teachers are regarded as the target audience. The initiative focuses on envisioning STEM women to serve as close role models to students.

Our objectives are closely linked to the promotion of the Sustainable Development Goals (SDGs) to educate children as future citizens acting as agents of change in policies that enable a more sustainable future in terms of equity, inclusion, diversity, prosperity, and justice. The project focuses on the SDG4 and SDG5 through the organization of outreach activities where students, their families, teachers, and STEM professional women are involved via the three main actions of the project: Girls4STEM Family Talks, Girls4STEM Professional Talks, and the Initial Training Seminars.

In this work, the project implementation is described in detail: the main organizing actions, the procedure to manage them, short-term, intermediate, and long-term milestones and results, and the agents and entities involved. In addition, recommendations for ensuring a sustainable implementation of the project over time are given. This information can be used as a White Paper for other institutions to adopt similar strategies.

In this first edition, the maximum possible number of registered centers for the Girls4STEM program was reached, reflecting the good reception of the initiative among the School Centers and STEM experts (more than 100 experts enrolled). In addition, attendance in both Family and Professional

Talks was very high, reaching full capacity in all sessions and the perception of the attendees being positive about the format and the duration. The analysis of the data collected through the designed surveys has indicated that efforts towards breaking stereotypes related to STEM studies should start by spreading and clarifying which disciplines are in STEM areas. Secondly, results show that girls seem to be less self-confident about their performance in STEM disciplines. This lack of self-confidence in girls points out that is mandatory to eliminate prejudice and improve girls' self-confidence in STEM areas, since the evidence shows that self-confidence in STEM determines a greater persistence in these areas over time.

Based on the evaluation and the experience of the first edition, and following the path towards our long-term goal, the project will ensure a larger participation of primary schools, since the evidence points out that the gender STEM gap starts already around the age of 6. In addition, aspects related to self-efficacy and perception from others will be further evaluated through the improvement of the evaluation tools.

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