Mentoring female high school students for a STEM career

Noelia Olmedo-Torre, Marta Peña Carrera, Mireia López-Beltrán, Maica Sanz Gómez & David López
Institute of Education Sciences
Universitat Politècnica de Catalunya (UPC·BarcelonaTech)
Barcelona, Spain
n.olmedo@upc.edu, marta.penya@upc.edu, mireia.lopez.beltran@upc.edu, maica.sanz@upc.edu, david@ac.upc.edu

***Abstract*—This Innovative Practice Work in Progress Paper presents a pilot test designed to train university students of engineering degrees (mentors) to advise and guide students aged between 15 and 16 (mentees) in technological fields in different teaching centers in Catalonia. The first results suggest the high interest shown by the group in the talks of the mentors; a greater attention and predisposition of the male students are observed in the questions and interventions. The sensitization of the female group on STEM issues is surprising, although there is a low participation and interest shown by the topics discussed. All these aspects must be taken into account in the planning of future interventions.**

Keywords—Diversity; Gender; Female; STEM

I. INTRODUCTION

Several EU member states have expressed concern on two issues: the proportion of students entering Sciences, Technology, Engineering and Mathematics studies (STEM) is not increasing to the required level and the under-representation of women persists. In addition, the lack of scientific vocation of girls for technological studies is accentuated the more developed the country is [1]. For this reason, initiatives and programs are being designed to address these issues, focusing on science education and attracting young people to science, with special attention to girls.

The low percentage of women who choose STEM careers perceives engineering, in general, as a work of men [2-5]. This vision misses the incorporation of women and the wealth and experience of their approaches is wasted [6-7]. It is clear that strategies must be developed to capture female talent in future promotions of technological studies and determine the factors that define the characteristics of women who choose to study technological careers with the interest of attracting them in the coming years [8-9].

The related literature shows that there are several factors, sociocultural and structural, that influence the technological vocations of women at the time of the choice of their university studies. It is possible, according to several studies, that gender stereotypes discourage women from pursuing STEM studies and desist from opting for related work. Early participation in STEM activities, together with family support, contribute to the interest and motivation in technological studies [10-11].

The disaffection of women for studies related to engineering and technology is evident in a study [12] carried out among students in 3rd and 4th year of Compulsory Secondary Education (CSE). They are considered less skilled with Information and Communication Technologies (ICT) and show a lower degree of attraction for technology and information technology. The main difference lies in the confidence in their abilities to pursue these studies: only 71% of girls feel capable of studying engineering and computer science, compared to 85% of boys, despite having better academic records than them. In addition, stereotypes/negative gender models have been detected in relation to women and technology, so the perception of pre-university women is still negative in order to pursue a technological career even with a good academic record.

The universities specialized in the areas of engineering and architecture have shown constant concern for the low number of women who, at the end of their secondary learning stage, choose STEM studies. With the aim of reversing this situation, they have carried out a series of actions in the field of secondary education, such as lectures in schools, open days, participation in conferences and debates, and awareness actions inside and outside school in order to highlight technical studies and promote the image of women as a reference for younger women. However, inequalities in science and engineering persist, and women remain a minority in technical schools around the world. In 1997, the Polytechnic University of Catalonia. UPC·BarcelonaTech (UPC) (www.upc.edu), a Spanish public university specialized in the fields of engineering, architecture and ICT, has incorporated into its strategic plans the concern for the small number of women who, at the end of their secondary learning stage, choose technological studies.

The strategic lines of the III Gender Equality Plan 2016-2020 [13] of UPC follow the recommendations of the Conference of European Schools for Advanced Engineering Education and Research (CESAER) [14] network of European technological universities of which UPC is a member.

Currently 60 % of students who complete their studies in Spanish universities are women and of that 60 %, approximately 30 % have studied engineering or technology. The undergraduate studies with the fewest students enrolled in new enrollments (below 20 %) at UPC, according to data from the 2015 course to 2016, are those of computer engineering; telecommunication engineering; naval, marine and nautical engineering; industrial engineering and aerospace engineering.

978-1-5386-1174-6/18/$31.00 ©2018 IEEE

On the other hand, more than 70 % of the students enrolled in the degrees in health sciences and technologies are girls, and in the degrees in architecture, urban planning and building, they are almost 50 %.

The need to encourage and support women to study STEM is definitely evident. To increase the attraction of women to STEM studies, we must focus on future local students, although the problems of our region are similar throughout the EU and similar measures can be applied in both cases.

In this context, the project presented here, as a pilot phase, proposes using mentoring among women as a tool to motivate and accompany scientific-technical vocations among high school girls (mentees) by establishing a relationship with a university student (mentor) that inspires and guides the search for information in relation to STEM studies.

Several studies confirm that the participation of university students in mentoring activities improves organizational skills and commitment in similar activities. Students believe that a good mentor should be dynamic, specialist in the subject to be mentored and involved, among other aspects [15-16]. Other authors describe that their motivations are dominated by the need to help others and understand themselves and others, regardless of race and/or ethnicity [17].

The mentoring project, called t'STEAM [18], is organized by the UPC Institute of Education Sciences (ICE) with the support of Gabinet d'Innovació i Comunitat which since mid-2017. The project does not only consist of the mentoring sessions in couples but also includes a series of actions in the field of secondary education, such as lectures in schools, open days, participation in conferences and debates, awareness actions inside and outside UPC, in order to highlight the technical studies and promote the image of women of scientists and technicians as a reference for younger women. It is intended to have a mixed project that combines some activities with the entire group of mentors and mentees; mentoring sessions of each couple and participation in an activity organized at UPC to promote scientific vocations (such as Girls in ICT Day or Ada Love Day).

The objectives that are intended to achieve in this project are:

- For the mentees: support STEM vocations and bring the university closer to mentored secondary girls; show a close and useful science and technology with attractive professional opportunities; provide resources and information on STEM studies to empower mentored girls in the choice of their university studies.

- For the mentors: create links of solidarity of gender; favor the relational competences of the mentors and their leadership capacities.

- For the university community and high schools: sensitize in the area of segregation due to gender issues; demystifying the existing relationships between gender and branches of studies in order to break with the gender constraints when choosing the professional path and to encourage mentoring as a tool for the pre-university orientation of the student.

To carry out the pilot plan, we will work with 5 to 6 couples to monitor the process and analyze the possibilities of improvement for future editions. Likewise, a semester is defined as the duration of activities between mentor and mentee to facilitate the availability of the mentor that is usually conditioned by the semester of the university.

Different references of success have been taken into account to develop this project and the literature on successful cases in university-level tutoring has been reviewed [19-21].

Although this work is a pilot study it is a great opportunity to continue researching a greater number of students and mentors and to detect strengths and weaknesses of the actions that should be followed in a long-term project.

II. METHODOLOGY

The Networks and Mentoring Working Group at UPC was set up in November 2016 as part of axis 5 action 5.1 of the III Gender Equality Plan 2016-2020 to develop a mentoring program between UPC students and high school students. The working group consisted of 4 teachers, 2 administration and services people and one student (all belonging to UPC).

The selection of mentors was conducted with personal contacts (they had to be students from UPC) to have prior confidence with them and to be able to extract good feedback. However, in the future it will be necessary to design a communication and recruitment plan with the aim of reaching all UPC students. Regarding the selection criteria for mentors, they had to have motivation for the project and sensitivity for gender issues and that have temporary and territorial availability to assume the responsibility and commitment of mentoring.

After the selection, an informative and face-to-face training session was held to detail the main aspects of the project and strengthen its commitment to participate. They were trained on how to create a climate of trust, establish a relationship of empathy, an introduction to coaching tools for presentation and first contact, resources for conversations, listening and emotional empathy, management of frustration and role-playings to learn to guide the mentees.

The group consisted of 10 mentors: 5 were students of the Degree in Computer Engineering, 2 of the Master's Degree in Industrial Engineering, 1 of the Degree in Industrial Technologies and 2 of the Degree in Architecture. Before the training session a mentor communicated that she would not continue to be linked to the project due to lack of time and two other mentors stopped participating for personal reasons.

The high schools were selected from those centers that had previously participated in different activities with the university. It was determined that the action plan began with a face-to-face session in three selected high schools. Moving the mentors to the schools was considered a positive aspect and would establish a more direct connection with the mentee students and sensitize not only the girls, but the whole group.

The group chosen to participate in the experience was left in the hands of the faculty of the high school. In all three cases, it was students from the last year of their compulsory studies

(between 15 and 16 years old) who were studying the optative subjects of Technology or Computing.

In the design of these first sessions, several aspects were relaxed in the interested centers: It was left to the discretion of the teaching center to choose whether the workshop was held in a class for that purpose or within optative subjects (Technology and Computing). Another option to choose was to make the session only for girls or for the whole group. Finally, the three centers chose to do the workshop within optative subjects and for the whole group (boys and girls).

For the dynamization of the first session at the high schools the contents agreed with the mentors were designed. The session was structured with a presentation of the project and input of data on the lack of female vocations in STEM courses, presentation of the mentors and their experience as STEM university students, holding a workshop with the students to show the proximity and usefulness of the STEM, motivational video of the STEM degrees, presentation of the next phase of the t'STEAM Project. At the end of the session, the girls were offered the possibility to continue participating in this project and a form was provided in which they expressed their interest in continuing with a personalized mentoring (it involved the authorization of the parents or legal guardians).

At the end of the sessions at the high schools the group of mentees will be formed from the applications received. In the registration form a small motivation brief is requested that will serve to form the couples. The communication of the mentor-mentee couples will take place in the first meeting at the university. From this moment mentor and mentee will organize themselves to arrange the first mentoring meeting. For this session in couples, mentors have the training received and some guides developed by the working group.

The participation of the mentees in the t'STEAM project will be completed by attending an activity organized in the UPC (Girls in ICT Day), then there will be a second mentoring meeting in pairs and, finally, a final meeting of evaluation and closing of the project.

In addition to the benefits and motivations of mentoring, the UPC recognizes with 1 ECTS credit for 30 hours of dedication for mentors and certificates of participation for mentees.

The design of the pilot project was carried out taking into account a calendar of activities and a series of objectives to be achieved in this first phase (Table 1).

In parallel, and at the end of these activities, an online questionnaire made with Google Forms® was sent to the different participants of this project to analyze their perceptions (mentors, mentees, teaching centers and teachers). At the end of the survey, they were asked to add those comments that they considered appropriate for the improvement of the project.

TABLE I. DESIGN OF THE PILOT TEST

Schedule	Activity	Objectives
December/ January	Selection and information to mentors	Report the project to the mentors and plan the next actions
January/ February	Selection and information to high schools	Report the project to the centers and encourage participation
February	Training of mentors	Develop the skills necessary to train the participants in the role of mentor
March/ April	High schools activity	Show a science and a nearby and useful technology with attractive professional outings.
April/ May	Meeting at the university	Formation of mentor-mentee couples
May	First encounter mentoring couples	Space between mentor and mentee to establish a relationship of trust that allows the mentor to guide the mentee in her objectives
	Attendance activities for the promotion of scientific vocations	Participate in an organized activity at UPC.
June	Second encounter mentoring couples	Space between mentor and mentee that allows the mentor to guide the mentee in her objectives
	Closing	Group activity for all couples to value participation in the project

III. RESULTS

The training session of 4 hours was well valued in its contents although it was valued to do it in a split manner with a first session at the beginning of the project and a second session after having done a mentor-mentee meeting.

It was planned that the information sessions held in the three selected high schools were attended by two mentors and one member of the working group. At the end of the session, the documents to enroll in the mentoring project were distributed among the girls attending.

In the first high school (Canet de Mar) the session included a workshop in which a current case (bitcoins) was exposed. The two mentors were students of the Degree in Computer Engineering. 30 students participated (22 boys and 8 girls). The workshop was included in the optative subject of Computing.

In the second center (Mataró) the pilot test was presented by the center's own teacher and girls were encouraged to enroll in the project.

In the third high school (Barcelona) the session (included in the Technology optative subject) included a workshop on an electric motorcycle. The three mentors were students (2 of the Master's Degree in Industrial Engineering and one of the Degree

in Industrial Technologies). 22 students participated (14 boys and 8 girls).

Evaluation of the face-to-face sessions:

A. The mentors

They are essential. The generational proximity with the students, the vocabulary, the costumes, and in general various elements related to non-verbal communication, causes a positive effect. The high willingness of the mentors is highlighted, which has made it difficult to put together the hours of the sessions of the schools with their availability. The exams, the hours of class, the works, the practices have been some of the impediments that have caused that one of the sessions, agreed initially, could not be celebrated. On the other hand, although the sessions were prepared in advance, the success of the presentation depends on the oral communication skills of the mentors. The efforts of the mentors during the sessions are highlighted. Their presence and attitude influence the success of the activity.

B. The students

The selected groups already show an interest towards the STEM studies when they are studying two optative subjects related to technology. It highlights the inequality between girls and boys, the latter in greater numbers. It has been observed a greater interest and predisposition of the boys at the time of asking questions and interventions, although in the initial presentation emphasis is made on the low participation of the girls. From the active observation made, a high interest shown by the whole group emerges.

C. High school teachers

Teachers who accept this type of session already show interest towards the goal of awakening scientific-technological vocations among their students and especially among girls. Active and spontaneous participation has been observed in them. The teaching staff is respected by their students and proposes the session as a volunteer.

D. The sessions

The development of the sessions was correct. Timing, structure and content were adjusted to the profile and demands of high school students.

E. The member of the organizing team of the project

The intervention of a member of the organizing team gives security to the mentors and constitutes the meeting point with the faculty and the center. In addition, she has resources to fill the silence of the mentors, which were sometimes latent.

A quantitative evaluation was carried out for the extension and generalization of the experience in the future. The indicators of success and quality will serve to define the second phase of implementation of this activity.

The ten mentors who answered the survey considered that they had found themselves comfortable throughout all the sessions and agreed that the activity had been useful for the students, but they disagreed to a large extent that the format had een adequate for the students. Regarding time and content, this fact makes us rethink this activity and take the necessary measures to adapt it to the needs of students and mentors. All mentors agreed that mentoring can motivate girls to pursue STEM studies. Among the comments of the mentors, the low participation of the girls in the sessions stands out. Another mentor points out that the attention of boys has been much more than girls (although they expected it) and that the students felt little questioned since the boys took much of the space. Perhaps a non-mixed format would be more appropriate to encourage girls, they add as a comment.

The 18 high school students who answered this survey consider that the activity has been useful. 55% of them (girls and boys) say that the information provided by the mentors has made them rethink the choice of studies in the future. When the girls are asked if they have felt identified with some of the things that the mentors have said and if the activities had made them think, 78% agreed and strongly agreed. These responses are very positive and encourage us to continue advancing with this mentoring experience by extending the proposal to more secondary schools throughout Catalonia.

Finally, secondary schools stand out as a whole that the activity has been useful for students and recommend that these sessions be done in 3rd of CSE to encourage more girls to take the elective course of technology in 4th of CSE. The centers also recommend that tools be introduced so that students can participate and interact more actively.

IV. Conclusions

The positive aspects of this experience include the involvement and predisposition of the teachers in the teaching centers, the closeness of the mentors with the mentees and the contents of the sessions that facilitate communication with the group of students. The decentralization and the choice of centers in the periphery of Barcelona is an aspect that they value positively.

Among the aspects that should be improved for the next sessions are to train mentors in communication skills, lack of equity in class groups (more boys than girls) and improve the coordination of the schedules of the teaching centers with the availability of mentors. The organization of visits to the centers is made difficult by the plurality of schedules.

The validation of the calendar of activities and the obtaining of results with indicators that allow us to evaluate the experience is the next objective. This pilot test serves as an analysis and as a starting point to the extension and generalization of the experience in the future.

Acknowledgment

We thank the UPC Institute of Education Sciences (ICE UPC) for all the support received. Silvia Gómez-Castán (Gabinet d'Innovació i Comunitat de la UPC) and Sandra García Elfau (PAS ETSEIB). Also all the students, school centers, teachers, mentees and mentors who participated in this project.

REFERENCES

[1] C. Schreiner and S. Sjøberg, "The ROSE project An overview and key findings," *Oslo Univ. Oslo*, no. March, pp. 1–31, 2010.

[2] D. M. Hatmaker, "Engineering identity: Gender and professional identity negotiation among women engineers," *Gender, Work Organ.*, vol. 20, no. 4, pp. 382–396, 2013.

[3] E. Smith, "Women into science and engineering? Gendered participation in higher education STEM subjects," *Br. Educ. Res. J.*, vol. 37, no. 6, pp. 993–1014, 2011.

[4] G. Ranson, "Beyond 'Gender Differences': A Canadian Study of Women's and Men's Careers in Engineering," *Gender, Work Organ.*, vol. 10, no. 1, pp. 22–41, 2003.

[5] M. Sáinz and J. Müller, "Gender and family influences on Spanish students' aspirations and values in stem fields," *Int. J. Sci. Educ.*, vol. 40, no. 2, pp. 188–203, 2018.

[6] M. López-Sáez, J. F. Morales, and A. Lisbona, "Evolution of gender stereotypes in Spain: traits and roles.," *Span. J. Psychol.*, vol. 11, no. 2, pp. 609–617, 2008.

[7] M. Bartusiak and M. Bartusiak, "Why women in science are lonely - and shouldn't be?," *The Washington Post*, 2015.

[8] A. García, A. Hurtado, and B. Aranda, "Why Don't Girls Choose Technological Studies? Adolescents' Stereotypes and Attitudes towards Studies Related to Medicine or Engineering," *Psicooncologia*, vol. 12, no. 1, pp. 129–140, 2015.

[9] D. Puig Calvet, "Enginyeres a Catalunya: de les pioneres fins als anys 80," *GIOPACT*, p. 151, 2011.

[10] N. Olmedo-Torre, F. Sánchez, N. Salán, D. López, A. Perez-Poch, and M. López-Beltrán, "Do Female Motives for Enrolling Vary According to STEM Profile ?," *IEEE Transactions on Education*. pp. 1–9, 2018.

[11] K. Talley and A. Martinez Ortiz, "Women's interest development and motivations to persist as college students in STEM: a mixed methods analysis of views and voices from a Hispanic-Serving Institution," *Int. J. STEM Educ.*, vol. 4, no. 1, p. 5, 2017.

[12] Obra Social "La Caixa", FECYT, and Everis, "Estudio sobre vocaciones científicas. Evaluación del impacto de las acciones de divulgación en términos de promoción de vocaciones científico-tecnológicas," 2015.

[13] Universitat Politècnica de Catalunya, "III Gender Equality Plan 2016-2020," *Aprovats pel Consell de Govern de la Universitat (Acord núm.* 133/2007). [Online]. Available: https://govern.upc.edu/ca/consell-de-govern/consell-de-govern/sessio-4-2016-de-consell-de-govern/12/aprovacio-del-iii-pla-digualtat-de-genere-de-la-upc/12-46-aprovacio-del-iii-pla-igualtat-genere-upc.pdf/@@display-file/visiblefile/

[14] Conference of European Schools for advanced engineering education and research." [Online]. Available: http://www.cesaer.org/en/home/.

[15] C. Cutucache, J. Luhr, K. Nelson, N. Grandgenett, and W. Tapprich, "NE STEM 4U: an out-of-school time academic program to improve achievement of socioeconomically disadvantaged youth in STEM areas," *Int. J. STEM Educ.*, vol. 3, no. 1, p. 6, 2016.

[16] M. Popescu-Mitroi and C. Mazilescu, "New perspectives on roles of the mentor-teacher for pedagogical practice," *Procedia - Soc. Behav. Sci.*, vol. 15, pp. 2078–2082, 2011.

[17] L. Nguyen, L. Rocha, C. Nguyen, B. Houchens, and A. Bautista-Chavez, "Volunteerism in Engineering Outreach : Motivations and Surprising Outcomes for Undergraduate Mentors," 2014.

[18] t'STEAM. Mentoring project." [Online]. Available: https://igualtat.upc.edu/ca/projectes-clau/mentoria/t2019steam.

[19] J. Yusta-Loyo, M. Cepero-Ascaso, J. Prieto-Martín, A. Abadía-Valle, and C. Bueno-García, "Peer Mentoring at the University Level: The Importance of Organization," *Procedia - Soc. Behav. Sci.*, vol. 196, no. July 2014, pp. 233–236, 2015.

[20] S. Carpintero, "Qualities That Mentors in the University Setting Should Have," *Procedia - Soc. Behav. Sci.*, vol. 197, no. February, pp. 255–258, 2015.

[21] T. Kunberger and C. Geiger, "The impact of near-peer mentoring on self-efficacy in an introductory engineering course," *Proc. - Front. Educ. Conf. FIE*, vol. 2016–November, pp. 4–7, 2016.