

# Fostering STEM vocations among secondary school girls through Service-Learning

## Fomentar las vocaciones STEM entre las alumnas de educación secundaria a través del aprendizaje-servicio

Belén Muñoz-Medina<sup>1</sup>, Sergio Blanco Ibáñez<sup>2</sup>, Marcos García Alberti<sup>1</sup>, Alejandro Enfedaque Díaz<sup>1</sup>, Rubén Muñoz Pavón<sup>1</sup>

mariabelen.munoz@upm.es, sergio.blanco@upm.es, marcos.garcia@upm.es, alejandro.enfedaque@upm.es, ruben.mpavon@upm.es

<sup>1</sup>Departamento de Ingeniería Civil: Construcción

Universidad Politécnica de Madrid  
Madrid, Spain

<sup>2</sup>Departamento de Mecánica de Medios Continuos  
y Teoría de Estructuras

Universidad Politécnica de Madrid  
Madrid, Spain

**Abstract-** This article describes a Service-Learning experience at the ETS de Ingenieros de Caminos, Canales y Puertos of the Universidad Politécnica de Madrid. The project has made it possible to implement activities to support education, specifically in the final years of secondary and baccalaureate education, and to encourage vocations in STEM (Science, Technology, Engineering, and Math) degrees, especially among secondary and baccalaureate women students in an area with a lower-than-average income level. To this end, female bachelor's and master's degree students presented their final projects to secondary school students. In this way, secondary school students could understand what civil engineering is and what types of projects are carried out in this field. The aim is to make engineering a possible life path for women and to ensure that the decision they make about their studies is not influenced by prejudices and false feelings of inadequacy.

**Keywords:** *Service-Learning; vocations STEM; Civil Engineering; secondary school girls.*

**Resumen-** En este artículo se describe una experiencia de Aprendizaje-Servicio llevada a cabo en la ETS de Ingenieros de Caminos, Canales y Puertos de la Universidad Politécnica de Madrid. El proyecto ha permitido poner en práctica actividades de apoyo a la educación, en concreto a los últimos años de educación secundaria y bachillerato y fomentar las vocaciones en titulaciones STEM (Ciencias, Tecnología, Ingeniería y Matemáticas) especialmente entre las estudiantes mujeres de educación secundaria y bachillerato situados en una zona con un nivel de renta inferior a la media. Para ello, alumnas de grado y máster presentaron sus trabajos fin de titulación a alumnos de educación secundaria. De esta forma, los alumnos de los centros de educación secundaria comprendieron qué es la Ingeniería Civil y qué tipos de proyectos se desarrollan bajo el ámbito de la misma. El objetivo es hacer la ingeniería un camino vital posible para las mujeres y que la decisión que ellas tomen sobre sus estudios no se vea influenciada por prejuicios y falsos sentimientos de no valía.

**Palabras clave:** *Aprendizaje-Servicio; vocaciones STEM; Ingeniería Civil; alumnas educación secundaria.*

### 1. INTRODUCTION

The annual reports published by the Ministry of Universities of the Spanish Government show that the presence of women in Bachelor degrees is in the majority, with a presence of 56% in the academic year 2020-2021, (Ministerio de Universidades, Gobierno de España, 2022) and this figure was maintained practically identical during the academic year 2021-2022, (Ministerio de Universidades, Gobierno de España, 2023). However, these reports also show that in architecture and engineering degrees the percentage of women is drastically reduced, 25.7% and 26.5%, in the academic years 2020-2021 and 2021-2022, respectively. The Universidad Politécnica de Madrid (UPM) is no stranger to this fact, although there has been a slight increase concerning the previous academic courses (Universidad Politécnica de Madrid, 2023). A similar situation is the case of the ETS de Ingenieros de Caminos, Canales y Puertos (School of Civil Engineering) of the UPM. This aspect is widespread in neighbouring countries and the European Union (European Union, 2023). Given these data, it is necessary to bring engineering, particularly civil engineering, closer to secondary and baccalaureate students, especially girls.

Service-learning is defined as learning by doing service to society, or in other words, the process of learning by doing community service to society (Centro Promotor de APS, 2012). The combination of learning and service to society provides great results, superior to those provided by the two separately. Other authors define service-learning as an innovative teaching methodology that enables students to develop civic responsibility and personal growth, (Aramburuzabala, et al., 2015).

This paper presents a service-learning activity through a series of activities in support of education. The activity was carried out under the umbrella of a competitive call for educational innovation projects (PIEs) according to the Service-Learning methodology. The activity had a double objective, on the one hand, to encourage STEM (Science, Technology, Engineering and Mathematics) vocations among secondary school student girls in neighbourhoods with low-income levels and a low percentage of the population with university degrees,

and on the other hand for female university students to improve their communication skills.

## 2. CONTEXT & DESCRIPTION

During the 2021-2022 academic year, female students enrolled in the School of Civil Engineering de la UPM represented only 27.2% of the total number of students. This data together with those shown in the previous section indicate that it is necessary to encourage STEM vocations, especially in civil engineering. To this end, the project described above was carried out, in which female university students, belonging to undergraduate and master's degrees at the School of Civil Engineering of the UPM, presented their final degree projects to secondary school students. This activity took place in Tirso de Molina secondary school, located in Puente de Vallecas, a neighbourhood with a lower-than-average income in the city of Madrid. During the event, undergraduate and master's degree female students presented their final projects to secondary school students. These projects consist of a civil engineering solution to real problems in society. In this way, secondary school students understood what Civil Engineering is and what types of projects are developed in the field. The main goal was to promote vocations for STEM degrees, especially among female students. But also, with the activity the university students strengthen their transversal communication skills by presenting their work to recipients who are not familiar with technical and engineering language. They also learn to synthesise and transmit the fundamental aspects of their work. The activity also improves the motivation of university and secondary school students.

To measure the impact of the activity on secondary school students, a survey was carried out before and after the activity. It included questions about their knowledge of (civil) engineering and how they see themselves as future engineers. The questions included in the questionnaire are presented in Table 1.

**Table 1.**

*Questions related to the evaluation of the activity (answers: yes/no/don't know or rating from 1 to 5)*

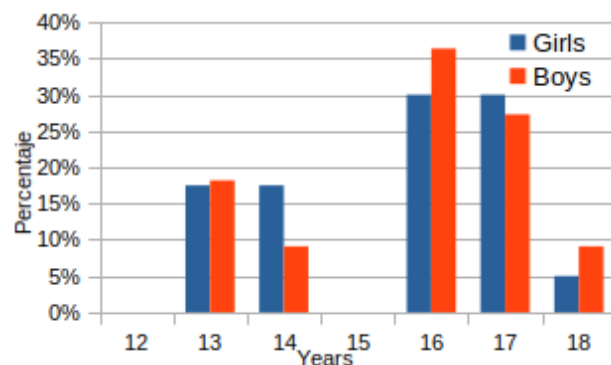
Q1	Do you know what a civil engineer does, and can you give some examples of projects he/she does?
Q2	What do you think about the difficulty of engineering studies? Please rate from 1 (not difficult at all) to 5 (very difficult).
Q3	Do you see yourself as a good future engineer?
Q4	Would you like to study for an engineering degree at university?

Source: Own elaboration

## 3. RESULTS

The presentations of the final projects of the degree in Civil Engineering were held at the Tirso de Molina secondary school, where the age distribution of students is shown in Figure 1. In this figure can be seen that most of the participating students are 16 and 17 years old, followed by 13 and 14 years old. These

ages correspond to the two participating academic years: 1st year of Baccalaureate and 3rd year of compulsory secondary education.

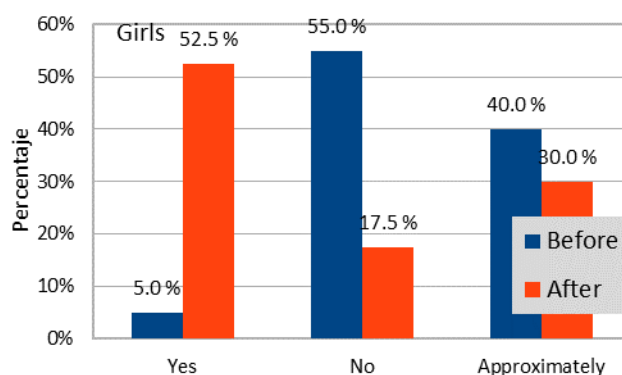


**Figure 1.**  
*Age distribution of students*

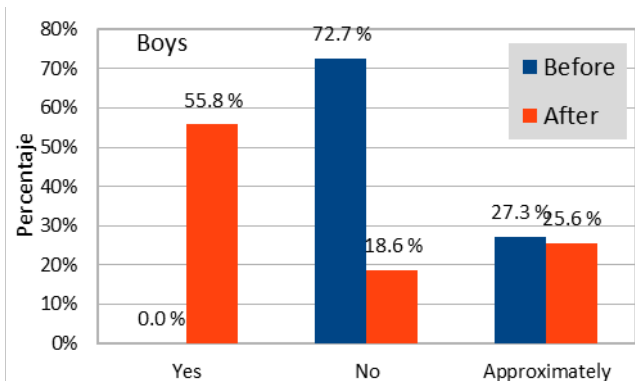
As indicated in section 2, the survey of secondary school students was carried out before and after the presentations. The aim of this methodology was to measure the influence of the presentations on the students' perception of civil engineering and of themselves as engineers. The results obtained for each of the questions in table 1 are described below.

We first present, in figure 2 for girls and in figure 3 for boys, the results corresponding to the question "Do you know what a civil engineer does? Could you give an example of projects that he/she carries out?" Both populations show a similar behaviour: they mostly do not know what a civil engineer is before the presentation and about half of them say they know what a civil engineer does after the presentation.

It is worth noting the very small percentage of students who stated that they know the profession of civil engineer before the presentation. In both cases, the percentage of those who still do not know what a civil engineer is or know it only approximately after the presentation is similar for boys and girls: 17-18% who do not know it and 25-30% who know it approximately.

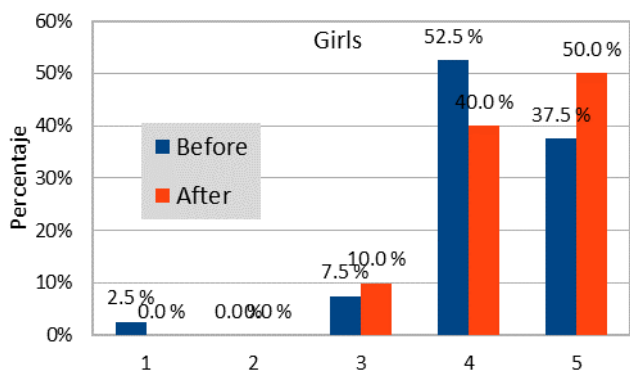


**Figure 2.**  
*Girls' answers to question Q1*

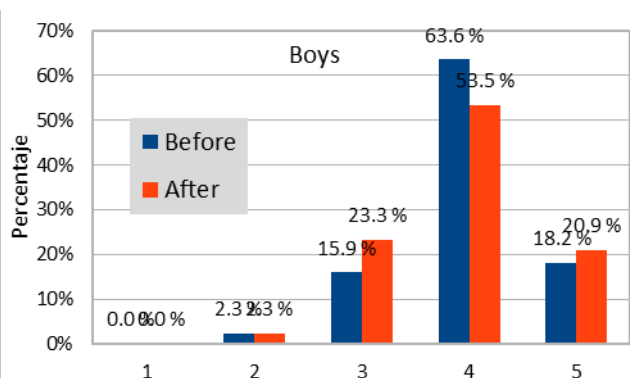


**Figure 3.**  
Boys' answers to question Q1

Below are the results related to the question "What do you think about the difficulty of engineering studies? Please rate from 1 (not difficult at all) to 5 (very difficult)" for girls (figure 4) and boys (figure 5) comparing before and after the presentation. While both populations consider civil engineering studies to be of high difficulty, the responses differ in that girls consider them in a higher percentage to be of maximum difficulty (37.5% before and 50.0% after) compared to boys (18.2% before and 20.9% after). Interestingly, the presentations have had the effect of increasing the perception of engineering studies as very difficult for both boys and girls.



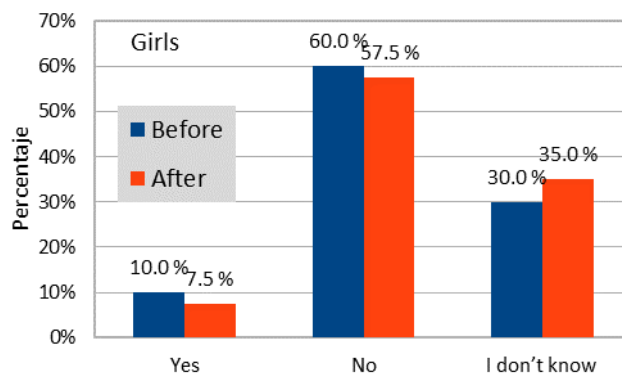
**Figure 4.**  
Girls' answers to question Q2



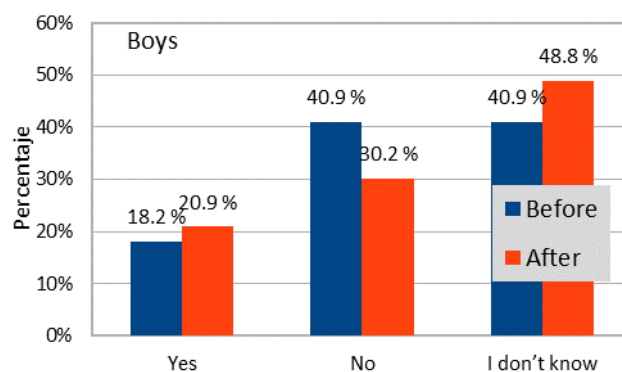
**Figure 5.**  
Boys' answers to question Q2

Figures 6 and 7 show for girls and boys the results corresponding to the question "Do you see yourself as a good future engineer?". We observe that the percentage of students who see themselves as a good future engineer is higher for boys

than for girls (approximately 20% compared to 10%). Moreover, the effect of the presentation was different for boys than for girls: for boys, the percentage of students who see themselves as a good future engineer increased (from 18.2% to 20.9%), while for girls it decreased (from 10% to 7.5%).

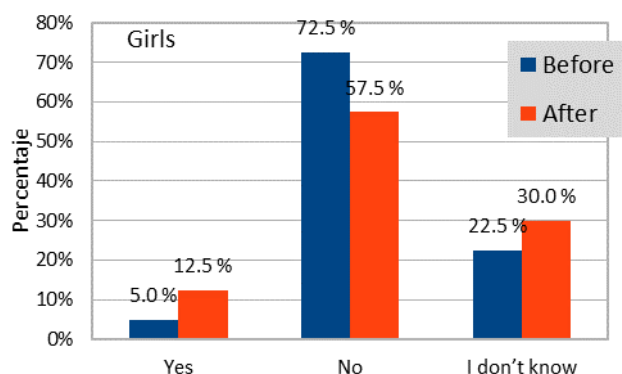


**Figure 6.**  
Girls' answers to question Q3

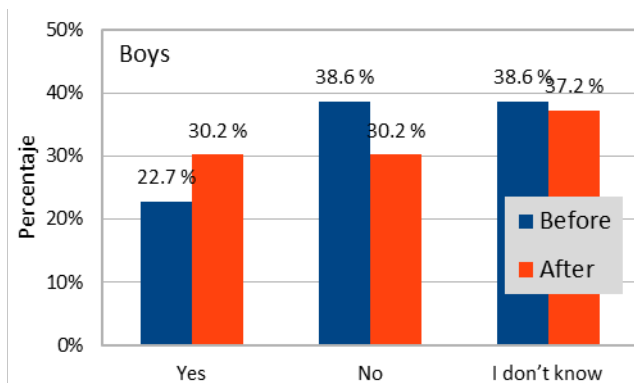


**Figure 7.**  
Boys' answers to question Q3

Finally, we show in figures 8 and 9 for girls and boys the responses associated with the question "Would you like to study an engineering degree at university?" As can be seen very few girls wish to study an engineering degree, while approximately one third of the boys do wish to do so. It can also be seen that the presentation has had the effect of motivating students to study an engineering degree: girls from 5% to 12.5% and boys from 22.7% to 30.2%.



**Figure 8.**  
Girls' answers to question Q4



**Figure 9.**  
*Boys' answers to question Q4*

#### 4. CONCLUSIONS

The first conclusion we can draw from the work is that the activity served to raise awareness of the activities of a civil engineer. As can be seen in figures 2 and 3, after the presentations, more than half of the boys and girls said that they knew what this type of engineer does. The second conclusion is that the work reproduces the social reality that girls see engineering as something alien to them. In a much higher percentage than boys, girls see engineering as very difficult, do not see themselves as future good and do not plan to study an engineering degree.

If we stick exclusively to the results before the presentation, we can highlight that students had almost no knowledge of the civil engineering profession. Both populations consider engineering to be a highly or very highly difficult field of study, although girls consider it to be of the highest difficulty in a higher percentage. It can be affirmed that boys see themselves in a higher percentage as good future engineers than girls, who perceive themselves as such in a lower percentage. Similarly, a higher percentage of boys than girls planned to study engineering during their university studies.

Regarding the main objective of the activity, to eliminate stereotypes that see engineering as something masculine and to help girls in secondary schools to visualise themselves as possible future engineers, we cannot be sure that this has been achieved. If we look at figure 6 we can see that after the activity the percentage of girls who see themselves as good future engineers has decreased after the presentation. This, together with the significant increase after the presentation in the percentage of girls who see engineering as something very difficult, suggests that the presentations have reinforced the girls' view of engineering as something unrelated to them. One possible explanation for this result may be that the presentations were not adapted to the age of the secondary school students, but used the same presentation that the university students presented in their final degree defence. This lack of adaptation may have been intimidating for some of the girls in the secondary school.

However, not all results are negative. Figure 8 shows that there is an increase (from 5% to 12.5%) of girls showing their desire to study engineering after the presentation. Although it is true that this increase is much smaller than that of boys, it suggests that there has been a part of the girls who have been inspired to see themselves as future engineers by seeing female university students presenting their final degree work.

The methodology used for data collection, passing a questionnaire to the students, has the limitation that the information collected is limited to the questions in the survey, which also introduces a certain bias in the perception of the interviewees. It could have been complemented with other methodologies, such as the focus group, which allow qualitative aspects of the phenomenon to emerge in an unconditional way from the interaction of the students with each other. It would be very interesting to collaborate with the teaching staff of the secondary school in order to explore other data collection techniques in the future to complement the one presented here. It should also be noted that this work is transferable to other populations of secondary school students in municipalities with a higher than average income, in order to study whether this socio-economic factor has an influence on the results obtained.

As a final comment, we can say that the activity is positive and necessary. Drawing inspiration from the example of other female students who have finished their engineering degree is a useful tool to motivate young girls to see themselves as possible future engineers. The aim is to make engineering a possible life path for women and to ensure that the decision they make about their studies is not influenced by prejudices and false feelings of inadequacy. At the same time, skills and values such as creativity, motivation and empathy were reinforced.

#### ACKNOWLEDGEMENTS

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