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Project “Acércate A La Ingeniería”: Impact Assessment And Satisfaction Questionnaire

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Project “Acércate a la Ingeniería”: Impact assessment and satisfaction questionnaire

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ABSTRACT

Engineering is a key discipline in today's society, as it is sustainability. Therefore, these are concepts that must be introduced in early educational levels. In this context, the project "Acércate a la Ingeniería" (Get closer to Engineering), designed and carried out by the Department of Education of the Government of the Canary Islands in collaboration with the Industrial and Civil Engineering School (EIIIC) of the University of Las Palmas de Gran Canaria (ULPGC), has arisen. This project brings together eighteen secondary schools (IES) from five of the eight Canary Islands. The aim of this project is to educate students to prevent their rejection of engineering degrees by the participation in different activities that brings them closer to engineering. Various questionnaires have been carried out in order to measure the impact this experience had on said students, as well as the differences between boys and girls in engineering matters and the satisfaction level of the participating groups. This paper focuses on the results obtained from said questionnaires and their analysis.

1 INTRODUCTION

As an indispensable part of the STEAM disciplines (science, technology, engineering, arts, and maths), engineering has a leading role in society's development. However, it suffers from a lack of qualified professionals as a result of the rejection of engineering degrees by young students (Ministerio de Universidades 2022). Moreover, sustainability, inherently related to engineering, is now becoming a key concept in our planet's future. Therefore, these concepts must be introduced to young students during their academic education.

In this context, the project "*Acércate a la Ingeniería*" ("Get closer to Engineering") has arisen. Eighteen secondary schools (IES) from five of the Canary Islands, alongside with the School of Industrial and Civil Engineering (EIIIC), of the University of Las Palmas de Gran Canaria (ULPGC), have participated. The aim of this project is to educate students about engineering and sustainability, using the control of invasive plant species as the general theme of the project.

To measure the impact of this experience, some questionnaires have been carried out. This paper focuses on the results found between the experimental and control groups in the initial questionnaire, as well as the differences between boys and girls answers, in order to study the existing gender gap in STEAM disciplines (Longe et al. 2019). Furthermore, the level of satisfaction of the experimental group during the visit to the Workshop "Las Cocinas" has been measured through a normalized questionnaire.

1.1 Sustainable Development Goals 2030 (SDGs)

Nowadays, sustainability has become a highly discussed topic. As a result, people are more aware than ever of the impact their actions have on our planet's environment. Students must be educated about this topic so they can take action from early ages and develop an environment-friendly mindset and lifestyle. Subsequently, this project is aligned with Sustainable Development Goals 2030 (SDGs). The following four have been the main focus:

- SDG 4 Quality Education illustrates that education enables upward socioeconomic advancement and is key to escaping poverty. In recent years, education has made great strides such as access, especially for girls.

- SDG 9 Industry, Innovation and Infrastructure focuses on the introduction of new technologies and the efficient use of resources, which goes hand in hand with inclusivity and sustainability. The introduction of digital design and manufacturing technologies, in this case, will encourage students to engage in more experiential learning.
- SDG 12 Responsible Consumption and Production is based on ensuring livelihood of current and future generations. This experience aims to contribute by showing students the possibility of generating products using sustainable plant-based or bio-composted materials.
- SDG 17 Partnerships for the Goals is achieved through the collaboration of the university with secondary schools, thus promoting learning at different educational levels.

1.2 STEAM Vocations

A lack of STEAM vocations has been detected among young (Tayebi, Gomez, and Delgado 2021; Sánchez-Martín et al. 2017), which is a cause of concern in the engineering field. Different factors, such as the believe that STEM degrees are too difficult or the absence of guidance when choosing a degree, cause students to reject engineering branches, according to studies carried out by the Spanish Association for Digitalization (2019) (Araña-Suárez 2022). Girls seem to be the ones that are more affected by this, as the belief that women face higher difficulties than men when studying STEAM degree is well established (Ng and Fergusson 2020). Some studies, that had been carried out by this research group, investigate the cause of this situation. The results obtained highlight the following aspects:

- Improving self-perception
- Generating connection with scientific-technological activities
- Generating meaningful experiences in early ages
- Increasing the number of references.

1.3 Maker Education

The maker movement brings together people known as Makers (engineers, artists, designers, and amateurs) to create and build new objects and product by embracing the concept *Do It Yourself* (DIY) (Kwon and Lee 2017). This dynamic has created new working spaces known as Makerspace, where these activities can take place. Makerspaces have arisen in universities and libraries, as well as in primary and secondary education, strengthening teamwork and fellowship among participants (Liberato et al. 2019). This has resulted in the concept of Maker Education (Martin, 2015). Through the Maker Movement and Makerspaces activities, this project has tried to encourage students to acquire STEAM vocations.

2 METHODOLOGY

2.1 Project description

This project is based on the design and implementation of a descriptive and practical experience. This experience was offered to the participant IES by the Educational Innovation Group in Manufacturing Engineering, part of the EIIC. These IES are assigned to one of three different areas, which are: Geomatics Engineering, Chemical Engineering and Industrial Chemical Engineering, and Engineering in Industrial Design and Product Development.

This paper focuses on the experience offered by the Engineering in Industrial Design and Product Development group. This professional activity has its centre of attention in products' life cycle, paying special attention to the actions taken during the design and manufacturing process of all type of products and taking sustainability into account. This includes the use of digital modelling and advanced manufacturing processes and technologies. In this experience, students received descriptive and practical information which they later made use of by designing a part. Moreover, they visited the Industrial Design Engineering Workshop called "Las Cocinas", located in the ULPGC campus. Here, students had the opportunity to acquire knowledge about various technologies, helping them comprehend the requirements for designing the part. Additionally, they were shown materials and objects based on natural fibres.

2.2 Objectives

The objectives of this project are the following:

- O1. Awaken the curiosity and interest of 4th of secondary school students in technology knowledge through workshops related to different specialties in the field of engineering.
- O2. To transmit the idea that engineering is the discipline that allows the implementation of knowledge, both scientific and technical, aimed at improving and facilitating the human being's daily life.
- O3. To bring students closer to the multidisciplinary nature of engineering.
- O4. To enable teamwork and the exchange of experiences of those centres interested in educational innovation in the field of engineering.

2.3 Phases

This project consists of five phases:

- **Phase I.** Initial meeting between the EIIC professors and the IES teachers. At this point, the initial questionnaire was shared with the IES teachers, who enabled students to fill it in. A part of this questionnaire is based on previous research (Ng and Fergusson 2020).
- **Phase II.** This phase consists of two different sessions, one at the centres and the other at "Las Cocinas". The first session is an introductory and demonstrative activity in the IES themselves taught by professors, researchers, university students and collaborators of the EIIC linked to the project. IES students are introduced to the field of design and develop new sustainable product based on the use of natural fibres from invasive species of plants. During the introductory activity, students are taught the knowledge of industrial design engineering, sustainability, invasive plants, and sustainable manufacturing of parts and tools. In the demonstrative part, students and IES teachers are shown an example of how their product will be manufactured. The second session is performed in "Las Cocinas" Workshop, where they learn first-hand about the advanced manufacturing technologies available there and perform hands-on activities. Furthermore, at the end of the workshop experience the students were asked to fill in a Course Experience Questionnaire (Wilson, Lizzio, and Ramsden 1997) to measure the level of satisfaction. A standardized questionnaire based on previous researches (Corbalan et al. 2013; Marsh, Touron, and Wheeler, n.d.).
- **Phase III.** In the third phase, the students together with the IES-teachers in their centres must design and develop a product following the requirements given. To facilitate this task, tutorials have been elaborated for IES students and their

teachers with the aim of showing them how to use a simple 3D modelling software, Tinkercad. Thus, using this software, students were asked to design a part. This part would be manufactured using resin 3D printing, followed by the creation of a mold through thermoforming, enabling the replication of the piece through gravity casting.

- **Phase IV.** In the fourth phase, each centre was asked to present their projects at the EICC with the aim of sharing what they have learned. Moreover, the students were asked to fill in the final questionnaire. The comparison between the initial and final questionnaire allows an impact assessment study.
- **Phase V.** A final report, which presents the results obtained, is completed and submitted for each school.

3 RESULTS

This paper focuses on the results obtained in the initial questionnaire, filled in by 4^o ESO students at the beginning of the project. The students who participated in this project are those who belong to the selected IES and are taking the Technology subject. This group is denominated the Experimental Group (EG). A group of students who have not participated on this project also filled in the questionnaire. This one is denominated the Control Group (CG).

The questionnaire is divided into two parts. The first one asks about basic information (IES name and student's gender). The second one is based on the Likert Scale, which shows the level of agreement and disagreement students have with the statements shown in **Table 1**.

Table 1. Statements of question number 4 of the initial questionnaire

p1	I'm aware about the climate change.
p2	The term sustainability is familiar to me.
p3	In my daily life, I take action to contribute to the creation of a more sustainable world.
p4	I believe that engineering can make the world more sustainable.
p5	If I learn engineering, I will be able to improve things that people use every day.
p6	I am good at building and fixing things.
p7	I would like to use creativity and innovation in my future job.
p8	Knowing how to use mathematics and science together will allow me to invent useful things.
p9	I would like to pursue a university degree.
p10	I believe I can be successful in an engineering career.
p11	I am interested in learning more about industrial design engineering.
p12	I am interested in learning more about chemical and industrial chemistry engineering.
p13	I am interested in learning more about geomatics engineering.

In the first 3 questions, which are generic and refer to the terms of sustainability and climate change, there is almost no difference between groups and genders. It was observed that all students were aware of these terms, as they have been mentioned before in the classroom. Mostly students indicated their familiarity with these terms when asked about them, but they were not capable of providing an exact definition. This was observed by the collaborators when visiting the IES.

Question p4 addresses engineering's capacity to enhance sustainability. A notable difference was found between the EG and CG. Over 80% of EG students believe

that engineering can contribute to making the world more sustainable. In contrast, the percentage is lower within the CG.

Similarly, in p5 "*If I learn engineering, I will be able to improve things that people use every day*", more than 80% of EG students answered with either "*agree*" or "*strongly agree*". Moreover, after the session in the IES, many students show a better understanding of the role that engineering plays in society. However, the percentages are lower in the CG, with approximately 70% of CG girls and 65% of CG boys expressing agreement.

Question p6 asks about the students' perception of their abilities to build and fix things. A difference is clearly seen between EG girls and CG girls. 43% of EG girls answered "*strongly disagree*" or "*disagree*" while 62% of CG girls answered the same. Therefore, a higher percentage of EG female students believe they are good at building and fixing things when compared to the other groups. They are followed by EG boys, CG boys, and lastly CG girls.

A significant difference between the EG and CG is observed in question 7. Over 80% of EG students would like to use creativity and innovation in their future job. Nonetheless, in the CG that percentage is lower, particularly among male students (58%). These results seem to indicate that students who study technology are significantly more interested in topics related to creativity and innovation than those who study other subjects.

Question p8 focuses on the usefulness of combining knowledge of mathematics and science in order to invent useful things. Approximately 75% of CG students, both boys and girls answered "*agree*" or "*strongly agree*". However, a slight difference was observed in the EG between genders. Female students considered mathematics and science more useful (85%) than male students (77%).

Regarding the desirability of pursuing a university degree (p9), the results are aligned with the current national data on education (Ministerio de Educación y Formación Profesional 2021). In both, EG and CG, it is observed that more than 80% of girls wish to pursue a university degree. On the other hand, 15% of EG boys answered "*strongly disagree*" while this percentage increases to 30% with CG boys.

In question p10, the possibility of success in an engineering career is explored. Both genders of EG students answered more positively than CG students. However, when comparing question p6 and p10, it is observed that EG girls think they could be successful in a smaller proportion, although they had previously established their capacity to build and fix things. This seems to suggest that girls do not tend to associate these abilities with engineering degrees, which reflects the existing lack of STEAM vocations in the female students.

As to students' interest in the different engineering branches which participated in the project, EG chose Design as their first option, followed by Chemistry and lastly Geomatics. CG chose Chemistry, Design and lastly Geomatics. All these results are shown in **Fig. 1**.

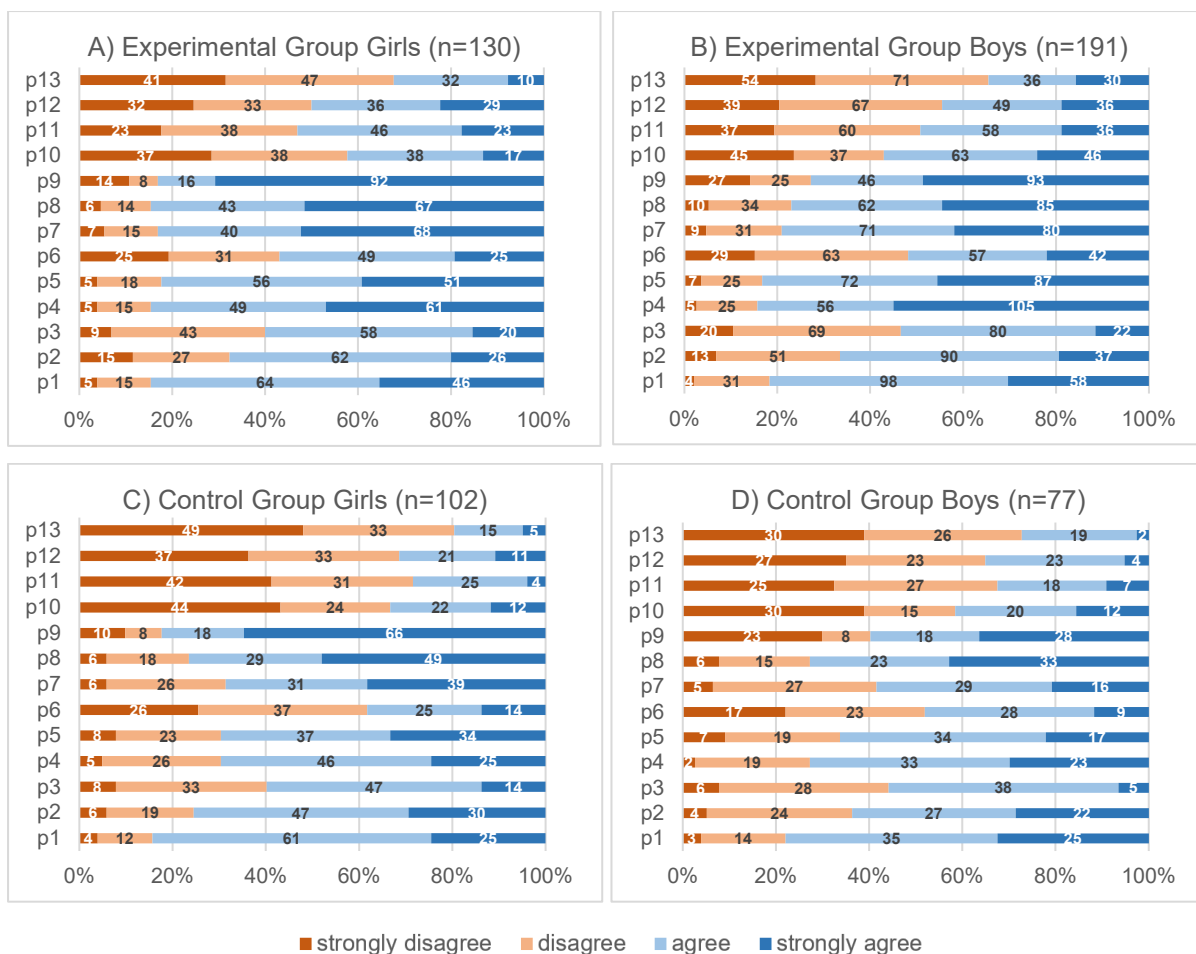


Fig. 1. Statements of question number 4 of the initial questionnaire.

The results obtained in “Las Cocinas” Workshop Experience Standardised Questionnaire are shown below in **Table 2**. Statements are arranged based on their average score (5 being the highest score possible).

Table 2. “Las Cocinas” Workshop Experience Standardised Questionnaire [CEQ]

Order	Statement	Average score
7	The activity was well organised.	4,49
6	The activity provided me with a wide perception of technology.	4,28
13	My participation in the activity was worth it.	4,26
20	The material provided during the activity was relevant and up to date.	4,24
19	The material provided during the activity was precise.	4,22
21	The information and communication technology used during the activity was effective.	4,21
14	I felt I was part of a group of students and staff committed to learning.	4,16
9	The activity was flexible enough for it to adapt to my needs.	4,13
10	I found the activity intellectually stimulating.	4,09
8	The activity's content was systematically organized.	4,08

17	Ideas and suggestions made by students were listened to and used during the activity.	4,08
1	The activity encouraged my enthusiasm for learning.	3,99
18	Available resources to help me learn were mentioned.	3,98
12	I found the activity motivating.	3,95
4	The activity developed my confidence to investigate new ideas.	3,86
15	I was able to explore my academic interests with students and staff.	3,86
2	My experience during the activity has encouraged me to value points of view different to mine.	3,79
16	I learned to confidently explore ideas with other people.	3,78
11	The activity has stimulated my interest about the topic.	3,74
5	I consider what I have learned to be valuable for my future.	3,72
3	I learned to apply the principles of this activity to new situations.	3,58

As shown in **Fig. 2**, it is remarkable the positive evaluation of the visit to “Las Cocinas” Workshop received, being approximately over 90% of answers “strongly agree”, “agree” or “neutral” in all statements. It is worth mentioning that statement number 7 “The activity was well organised” received a 67% of “strongly agree” answers and none “strongly disagree” answers. From the point of view of EIIIC collaborators, who adapted the activity in accordance with each group’s characteristics and needs, as well as the available time, it is remarkable that students perceived that the activity was well organised.

Furthermore, statement number 6 “The activity provided me with a wide perception of technology”, 85% of answers were “strongly agree” and “agree”, and none “strongly disagree”.

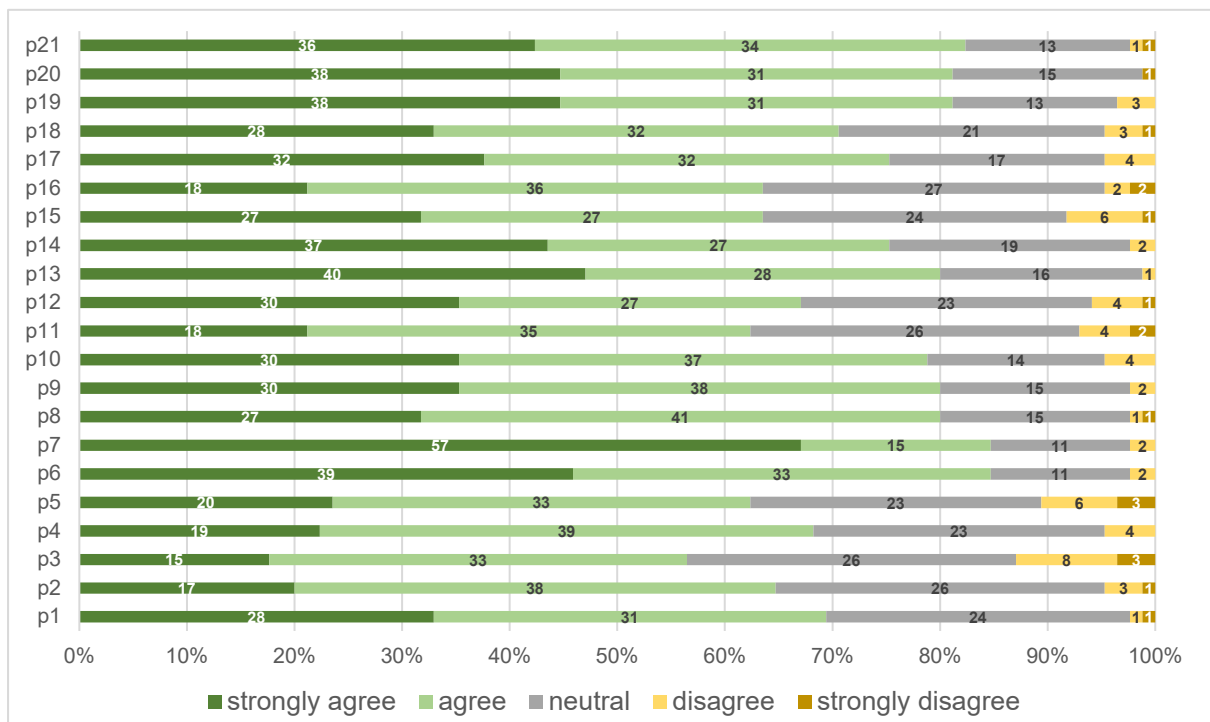


Fig. 2. “Las Cocinas” Workshop Experience Standardised Questionnaire [CEQ].

Once the project ended, it was observed that students of both genders showed a better comprehending of sustainability in the first three questions. Moreover, those questions focused on engineering, like p5, p7 or p10, indicated slightly fewer positive results. This may be attributed to the fact that, upon gaining a better understanding of what engineering entails, they become aware of its complexity. Thus, students perceive themselves as less capable of tackling it compared to their initial perceptions. However, during the visits made by students, it was observed that they indicated a higher interest in engineering degrees and saw them as a possible option to choose after high school, especially female students.

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