Role of Student Associations in the Acquisition of Competences in University Engineering Programs

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***Abstract*—Students in the STEM field (Science, Technology, Engineering and Mathematics), do not only require deep technical knowledge, but a complete set of global skills related to management, teamwork, lifelong learning, personal development, communications skills or proactiveness, abilities often referred as soft-skills. Student-led organizations, and specifically, university student associations, are one of the best alternatives to promote the acquisition of soft-skills in STEM high education fields. These skills are competences already included in official university programs that can hardly be addressed or acquired from traditional university education. This article studies how student enrollment in student led organizations (SLOs), with an active participation on their organization and activities, allows engineering students to achieve a better development of these soft skills. As case study, a medium size university, with 9000-students and eleven SLOs, six of them focused on STEM related fields, is used in this paper. A survey is conducted among the university community to identify their degree of participation in SLOs, and to test whether participation in these initiatives increases students' self-perception of their soft skill acquisition during their university studies. This survey shows how students of engineering programs, with a high degree of involvement in SLOs, demonstrated greater confidence in their soft skills at the end of their university years.**

Keywords—STEM, Soft Competences, Student Association, Student-led organizations, Renewable Energies

I. Introduction

In today's world, technology and globalization have allowed the development of an increasingly competitive and changing labor market. For this reason, students in the STEM field (Science, Technology, Engineering and Mathematics), do not only require deep technical knowledge in their field of studies, but a complete set of global skills related to management, teamwork, lifelong learning, personal development, communications skills or proactiveness, abilities often referred as soft-skills [1]. Student-led organizations (SLOs), such as student associations, are one of the best ways to promote the acquisition of these skills or competences for STEM studies [2], allowing students to become the leaders of the learning process.

However, there are several barriers to develop long-term successful SLOs experiences. Among these barriers are reduced student enrollment in SLOs [3], lack of resources, i.e. funding, space and resources for the development of activities [4], and lack of recognition from universities and formal curriculum [5].

In order to eliminate the existing barriers for SLOs at the Public University of Navarre (UPNA), a new regulation was established in February 2015. Additionally, grants for students associations steadily increased from 2200 € in 2016 to 17830 € in 2022, 1% of the overall grants given by the Public University of Navarre. This way, a stable frame was created that allowed the development of a different branch of student associations in the STEM field. Until that moment, student associations at UPNA were mainly focused on social and political aspects.

The first student association that emerged in the STEM field at UPNA, as a result of this new regulatory context, was APERNA (Student Association for the Promotion of Renewable Energies in Navarre), whose creation dates back to May 2015. After its creation, four other student associations in the STEM field have been constituted: i2tec (Association of Engineering Students for the Promotion of Electronic Technology), in 2017, AUTTEC (University Association of Automotive and Sports Technology), in 2019, Nabyte (Promotion of Computer Programming) and NavBiotec (Association of Biotechnologists of Navarra), both in 2020. In addition to those already mentioned above, there are six other associations at the Public University of Navarre that are not linked to the STEM field.

During the last years, these student associations have developed activities that might help to enhance soft-skills acquisition among STEM students, more precisely, in Engineering programs at UPNA. A survey has been conducted on a sample of 100 alumni from engineering programs at the university, fifty of whom belonged to student associations and fifty who did not. This survey aims to evaluate the degree of involvement of these students in student associations and the personal perception that students have regarding the soft-skills acquired during their university education. The aim is to study whether there is a correlation between membership in student associations and a greater development of so-called soft skills, as well as to demonstrate if active participation in such SLOs promotes further development of these skills.

The article is structured as follows. First, in Section II, the main competences included in the official programs of engineering degrees at UPNA are presented, focusing on those related to soft-skills. Subsequently, in Section III, the main activities promoted by SLOs, analyzing the specific case of APERNA, are presented, along with the competences that they allow to develop. Finally, in the assessment in Section IV, we analyze the data from the survey conducted among the members of the university community.

II. Engineering Programs and Competences Overview

The curriculum of the different engineering programs at UPNA, both at graduate and undergraduate levels, include a series of competences or skills that students must acquire. These competences can be classified into three categories: basic competences (BC), general competences (GC) and specific competences (SC). As an example, the competences

included in each category for the bachelor's degree in Industrial Engineering are detailed below, paying special attention to soft-skills, as they are the ones most influenced by SLOs.

A. Basic Competences (BC)

Among the basic competences, there are some related to hard-skills, such as the acquisition of cutting-edge knowledge in their field of study (BC1) or the resolution of problems within their field of study (BC2).

However, these competences also include soft-skills, such as the ability to make judgments on social, scientific or ethical issues (BC3), transmit ideas to both specialized and non-specialized audiences (BC4), or the ability to develop lifelong learning skills (BC5).

B. General Competences (GC)

This category includes eleven general competences, mainly focused on technical aspects and knowledge. Among these competences, GC1, GC2, GC3, GC5, GC6, GC8, GC9 and GC11 are mainly focused on engineering hard-skills. The remaining three competences include soft-skills such as, creativity, problem solving, decision making, the ability to transmit technical knowledge and critical thinking in the field of engineering (GC4), the capacity to analyze and assess the social and environmental impact of technical solutions (GC7) and the ability to work in a multilingual and multidisciplinary environment (GC10).

C. Specific Competences (SC)

This category contains the specific technical competences of the three intensifications available in the Industrial Engineering degree, i.e. Mechanical, Electrical and Electronic Engineering.

III. Activities Developed by APERNA and Competences Involved

As previously mentioned, there are several associations in the Public University of Navarra, four of them focused on the STEM field, whose members mostly study engineering degrees. The activities developed by these associations can be grouped into technical visits (TV) to companies and external entities, undergraduate and graduate thesis contests (TC), thematic conferences and workshops (CW), and thematic days (TD). With the objective of analyzing and studying specific initiatives within each of these broad groups of activities, any of the existing associations could be considered as a case study. However, this article focuses on APERNA, as it was the first of the STEM association at UPNA and, therefore, has developed the greatest number of activities to date.

APERNA is the Student Association for the Promotion of Renewable Energies in Navarra, an example of a student-led organization created at UPNA in May 2015. The objective of the association is thus to promote the knowledge and dissemination of renewable energies among the university community and the general society. The association was created after a talk on renewable energies at UPNA, in which Dr. Klaus Kuhnke, from the Hochschule Osnabrück, shared his experience with a student association focused on promoting photovoltaic solar energy, inviting those present at the talk to follow this example at UPNA. A group of students began organizing for the creation of this association, and that is how APERNA was born. Although the initiative was initially purely student-led, support was soon sought from UPNA professors specialized in Renewable Energies, with the aim of forming a technical committee to advise students when requested. Since its creation, the association has promoted a series of activities, organized by students, and in some cases, such as for the technical visits, in cooperation with the technical committee, that are summarized in Table I. In the same table, the number of times that a certain event has been organized is also detailed. Table I also summarizes the main engineering soft-skills involved in each activity. In the following, we analyze how these competences can be developed in the context of such activities.

TABLE I. Events Organized by APERNA and Soft-Skill Competences Involved

Activity	**Number of Events**	**Competences involved**
Student Welcome (SW)	5	BC4, GC4, GC10
Thematic Days (TM)	4	BC4, GC4, GC7, GC10
Undergraduate and Graduate Thesis Contest (TC)	8	BC3, BC4, BC5, GC4, GC10,
Technical Visits (TV)	7	BC3, GC4
Matlab Courses for Beginners and Advanced (MC)	7	BC4, BC5, GC4, GC10
Conferences and workshops (CW)	30	BC3, BC4, GC7, GC10

A. Student Welcome (SW)

Every year, coinciding with the beginning of the academic year, UPNA organizes a reception for new students. This is an event organized by UPNA with the aim of introducing new students to the various opportunities that the university can offer them, including student associations.

Student associations set up stands, see Fig. 1 (a), with the objective of showcasing the activities they organize and recruiting new members. Therefore, organizing and participating in this event allows association members to develop the following competencies or soft skills:

- BC4: transmit ideas to both specialized and non-specialized audiences. The future engineers who begin their studies in engineering possess limited technical knowledge. For this reason, students in higher courses must transmit clearly their ideas to a non-specialized public.
- GC4: creativity, decision making and the ability to transmit technical knowledge and critical thinking in the field of engineering. Associations try to attract new members, so they must be creative when setting up their stand and showcasing the activities they carry out to new students.
- GC10: new students who enter the university come from different backgrounds and regions, with different interests and even languages. Therefore, the student welcome event requires association members to work in an environment they may not have faced before.

B. Thematic Days (TD)

These thematic conferences or workshops focus on the dissemination of technical knowledge in the main areas of interest of STEM associations. In the case of the APERNA association, once a year, the *Sustainable Mobility and Renewable Energies* day is organized, see Fig. 1 (b).

This thematic day focuses on the dissemination of technical ideas related to renewable energy and sustainable

(a) (b) (c)

(d) (e) (f)

Fig. 1. Activities organnized by APERNA (a) student welcome, (b) Sustainable Mobility and RREE thematic day, (c) undergraduate and graduate thesis contest, (d) technical visits, (e) *Matlab* courses and (f) workshops.

mobility, to both specialized and non-specialized audiences. This dissemination must be done in an attractive way to engage the university community. Therefore, within this day, students are encouraged to try different sustainable modes of transportation, from electric bicycles to electric cars. Additionally, the public transport company brings an electric bus to the university. Talks and workshops are also organized to reflect on sustainability and the social and environmental implications of the current energy model. Considering this description, the main soft-skill competences developed by association members in the development and organization of this activity are:

- BC3: ability to make judgments on social, scientific or ethical issues.
- BC4: transmit ideas to both specialized and non-specialized audiences.
- GC4: creativity, decision making and the ability to transmit technical knowledge and critical thinking in the field of engineering.
- GC7: to analyze and assess the social and environmental impact of technical solutions.
- GC10: ability to work in a multilingual and multidisciplinary environment.

C. Undergraduate and Graduate Thesis Contest (TC)

This competition rewards the best undergraduate and graduate thesis carried out by UPNA students in the field of renewable energy. A jury, composed of engineering professors from different disciplines and a member of the association, evaluates the presentations given by the students as well as the posters created to support and illustrate their presentations. In Fig. 1 (c) appears the jury and participants of the 2021 edition.

A variety of competences are involved in this activity besides SC. Again, BC3, BC4, GC4 and GC10 play a relevant role. However, either as a contestant or as a member of the organizing committee, other abilities or competences become relevant, such as:

- BC5: the ability to develop lifelong learning skills.

D. Techcnical Visits (TV)

This is one of the most successful activities within the university community, as it allows students to learn about the reality of STEM companies. In the case of APERNA, some of the most relevant visits to leading companies have been the train company Talgo, the Gemasolar thermosolar power plant (see Fig. 1 (d)), the electric bus company Irizar, the Mutriku wave power plant, the ITER research center in the Canary Islands…

These technical visits involve hard-skills, but also some of the aforementioned competences BC1, BC3, GC1 and GC4.

E. Conferences and workshops (CW)

The associations organize various technical conferences and workshops throughout the academic year. In the case of APERNA, workshops on *Matlab* programming and Renewable Energies have been organized, as well as talks by professionals in the renewable and electro-mobility sector with lecturers from Spanish and foreign universities.

Some of the previously presented competences are developed within these activities, either in the organization, development or participation. As a a summary, the most relevant ones are BC1, BC4, BC5, GC4, GC7 and GC10.

These activities, besides allowing the development of competences, provide visibility to the association. With each of these activities, APERNA makes itself visible to the university community, thus enabling more students to become members of the association and develop their own competences. This correlation between the activities and the interest aroused by the association is shown in Fig. 2, in which the evolution of the number of members is represented

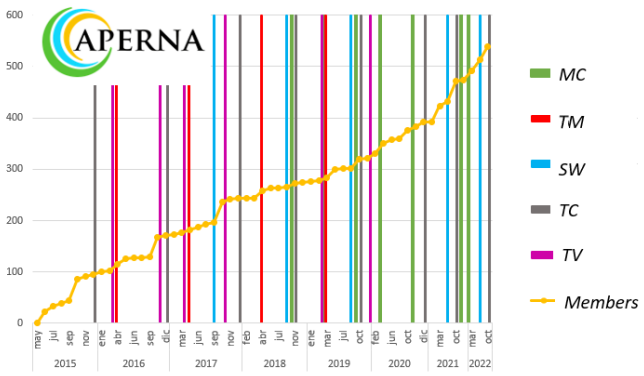


Fig. 2. Evolution of the number of members in APERNA as the different activities are organized.

together with the organization of the events listed in Table I. It can be seen how the student welcome is the activity that helps to gain most new members.

IV. Assesment: Contribution of SLO's to the Acquisition of Competences

In order to study the effect of active participation in SLOs, on the acquisition of the desired soft-skill competences in STEM engineering programs, a survey was conducted among the members of the university community using self-reporting questionnaires.

A. Design of the Survey

With the aim of obtaining a high number of responses among engineering students, and, thus, a significant sample, a short online survey has been designed, consisting of only 4 questions.

The first question is a classification question that allows respondents to be divided into two categories, those who have been part of student associations and those who have not. Thus, the first question asked in the survey is:

1- *Do you belong or have you belonged to any UPNA student association?*

If the result of this question is *No*, the respondent goes directly to the final question, question four of the survey. If the answer is *Yes*, the respondent proceeds to questions two and three:

2- *To which association/s?*
3- *Select the degree of involvement in each of these types of activities on a scale of 1 to 4 (1: Occasional passive participation, 4: Frequent active participation):*
   - *THEMATIC DAYS (TM)*
   - *UNDERGRADUATE AND GRADUATE THESIS CONTEST (TC)*
   - *TECHNICAL VISITS (TV)*
   - *CONFERENCES AND WORKSHOPS (CW)*

With these two questions, it is possible to identify, first of all, whether the respondent has belonged to STEM associations or to non-technical associations. This is relevant data since not all associations develop the same type of events, and therefore, the competences promoted by participation in each association are different. Secondly, it allows identifying the activities in which the respondent has participated the most, since not all activities organized by SLOs allow for the development of the same competences, as seen previously in Section III. Additionally, this question three allows to classify the respondent as an active member of an association, that is, someone who participates in the organization of the activities promoted by their association, or as a passive member, that is, someone who attends said activities but does not get involved in their organization. This information will be relevant to identify if active participation in SLOs allows for greater development of soft skills.

The last question focuses on the respondent's personal perception of their soft-skills development at the end of their university stage:

4- *How would you rate the level acquired in each of these soft skills at the end of your university stage?*
   - *Team work*
   - *Problem solving*
   - *Critical thinking*
   - *Integrity*
   - *Innovation*
   - *Creativity*
   - *Communication in technical and non-technical environments*
   - *Adaptation to change*

This question must be answered using the following Likert scale; Very low, Low, Neutral, High, Very High.

Although it may seem that the soft-skills evaluated in the survey differ slightly from those considered in engineering programs and explained in Section III, in reality, the list of soft-skills in the questionnaire evaluate different aspects of each competence. For instance, Team Work, evaluates GC10, Problem Solving GC4, Critical thinking BC3 and GC7, Integrity partially related to GC7, Innovation and Creativity GC4, Communication in technical and non-technical environments BC4 and Adaptation to change BC5.

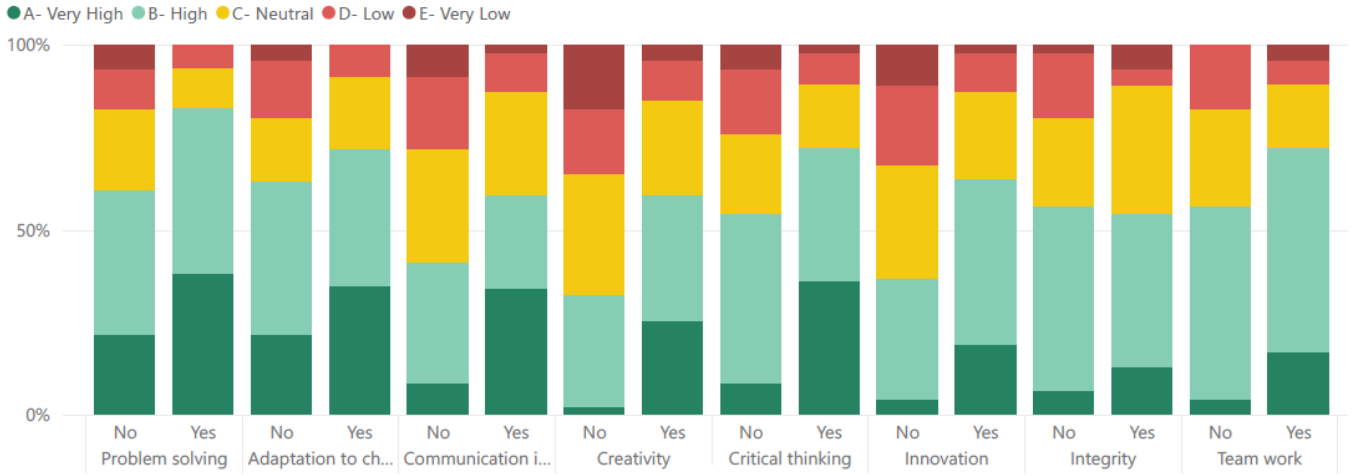
In this way, the survey should allow us to identify if there are differences in the respondent's perception of the development of soft skills that can be correlated to their enrollment in student associations, as well as to what extent the different activities organized by SLOs can contribute to promoting the development of soft skills.

B. Results

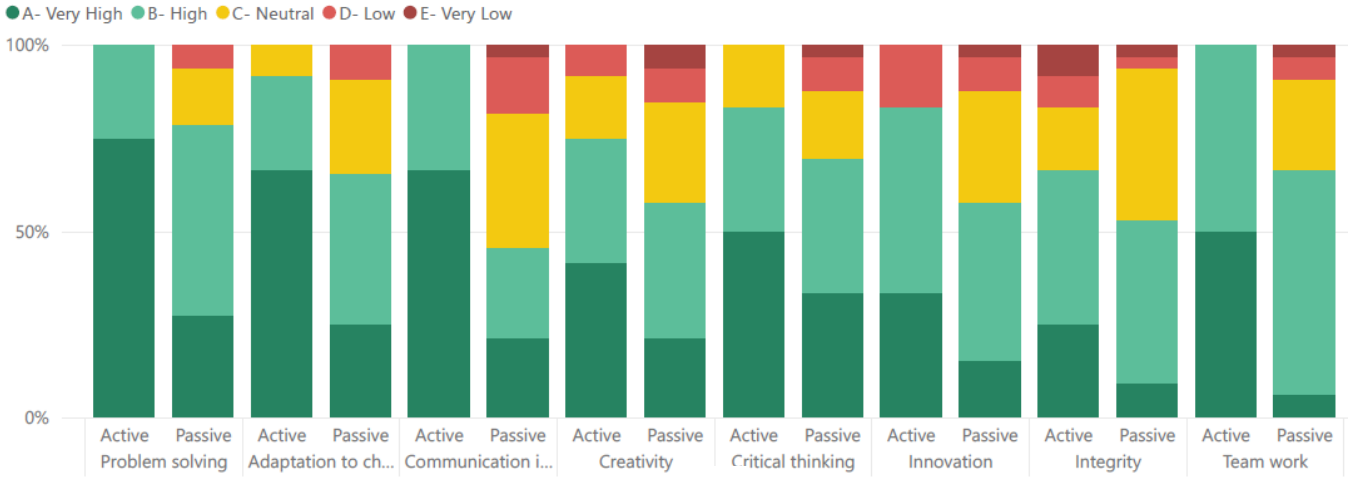
A sample of one hundred former engineering students was selected to complete the questionnaire, of which half had belonged to student associations during their university education, while the other half had not. Since the respondents' graduation, three years have passed on average, so it is a reasonable amount of time as to evaluate their soft-skills performance in the labor-market, while it is not too long as to modify their self-perception of those skills acquired at the end of their university stage.

The results obtained from the survey described above have been graphically summarized in Fig. 3.In Fig. 3 (a), the perception shown by the respondents on the development of soft skills acquired upon completing their engineering studies, divided according to whether the respondent belonged to student associations or not, has been represented. As can be seen from a first glance, respondents who belonged to student associations showed greater confidence in the development of the soft-skills surveyed in question 4.

Analyzing in more detail each of the competences, it stands out how in the first one, *Problem Solving*, 80% of



(a)



(b)

Fig. 3. Perception shown by the respondents on the development of soft skills acquired upon completing their engineering studies, (a) divided according to whether the respondent belonged to student associations or not, and (b) according to whether they had an active or passive participation in their respective associations.

respondents who belonged to associations, evaluated its development as *Very High* or *High*, while in the case of those who did not belong to any association, the percentage was 60%. These differences were less significant in *Adaptation to Change*. However, the percentage of respondents who belonged to student associations whose perception of the development of this competence is both *Very High* and *High*, exceeds that of those who did not belong to associations. In the case of *Communication in Technical and Non-technical Environments*, it stands out how in the case of students who did not belong to associations, the sample barely reflects cases with a *Very High* perception in this competence, while in the case of those belonging to associations, it exceeds 30%, and, in any case, the sum of *High* and *Very High* exceeds 56% of the results. A very similar conclusion can be drawn for the case of *Creativity*, *Critical Thinking* and *Innovation*. Finally, the results for *Team Work* are satisfactory for both groups, however, those who belonged to SLOs outperform the others in the *Very High* range.

The only competence in which differences are barely noticeable is *Integrity*, which may be due to the fact that, as seen in Table I, there are currently no activities developed by student associations specifically promoting this competence.

From the analysis of Fig. 3 (a), we can conclude that student associations foster the acquisition of soft-skills. Additionally, some of them, such as *Creativity*, *Innovation* or *Communication in Technical and Non-technical Environments*, in which not even half of the surveyed students who did not belonged to SLOs showed *High* or *Very High* perceptions, demonstrate that there are skills that are very difficult to develop from the purely academic environment of the classroom.

There are also differences in the development of these competences depending on the degree of participation in student associations and the activities they carry out. Thanks to question three of the survey, it was possible to classify association members as active or passive. The personal perception of the development of soft-skills for each of these categories of association members, has been graphically summarized in Fig. 3 (b).

Active members are considered to be those who organize the activities of student associations, so it is not surprising that there are significant differences in most competencies, as is the case with *Problem Solving*, Adaptation to Change, *Communication in Technical and Non-technical Environments*, *Innovation* and *Team Work*.

Finally, to fully analyze the benefits that membership in student associations provides for STEM students, it is very interesting to compare the results from Fig. 3 (a) and Fig. 3 (b). If we compare the results of active members of student associations with those who never belonged to such associations, it is remarkable that among active members, in all evaluated competences, the sum of *High* and *Very High* perceptions exceeds 65% of the results, while in the case of those who did not belong to associations, there is no soft-skill with *High* and *Very High* perceptions that exceeds 60% of the results.

The main limitation of this study is that it only allows to demostrate correlation, but not causality. To do so, it would be necessary to know the self-perception of the students in the sample at the beginning of their university education.

V. Conclusion

This paper studies the influence of student-led organizations on the acquisition of competences in high education studies in the STEM field. It can be concluded that students who belonged to associations have a higher perception of the development of what are known as soft-skills. Specially relevant is the case of active members of student associations, who organize the activities of such associations. These students exhibited the highest self-perception of soft-skill development, outperforming the rest of students. Additionally, the study reveals that there are skills that are very difficult to develop from the purely academic environment of the classroom.

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