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Peer Learning and Research Culture Within Student Organizations in Engineering: Students' Perceptions

K. Galantini Velarde[1], L. Cáceres Montero[2], A. Pachas[3]

[1] Architecture Program, Universidad de Lima, Peru
[2, 3] Civil Engineering Program, Universidad de Lima, Peru
[1]KGALANTI@ulima.edu.pe
[2]ludymargaritacm@gmail.com
[3]20171120@aloe.ulima.edu.pe

Abstract: Learning-centered models require using interactive methods, such as peer learning. In this context, student organizations are introduced as groups of students managed as autonomous extracurricular spaces in which they enrich their training process upon practical issues that promote peer learning, while encouraging lifelong learning (LL). Thus, this research explores undergraduate engineering students' perceptions about the influence of student organizations on the promotion of undergraduate research culture through a survey. Results have indicated that 91% of the surveyed students think thatresearch is encouraged within these spaces, and 79% perceive that these organizations have provided themwith the necessary support to start a research project.Finally, 87% have begun to consider research as an important factor for their professional development, in accordance with LL. Therefore, it was concluded that the promotion of undergraduate research culture within these organizations strengthens students' intention to develop their final degree project as a research paper.

Keywords: Peer learning, Student organizations, Research culture, Engineering education, Research competencies, Lifelong learning

1. Introduction

Currently, higher education institutions lay the foundations of their training processes upon competency-based curricula, as these focus on integral performances to reach previously established professional goals [1, 2]. Competency-based curricula are set to develop students' specific competencies, which are also known as hard skills, as well as generic competencies or soft skills [3], such as leadership, problem solving, communication, critical thinking, teamwork, among others [4, 5]. In fact, these curricula are based on achieving the learning potential of every student, so that they can build, consolidate, rebuild and deploy the necessary knowledge, skills, attitudes and values to effectively overcome the permanent challenges of their professional environment through time [6]. Hence, competency-based curricula enhance lifelong learning (LL), a competency itself [7], since they allow the development and reinforcement of competencies for learning to know, learning to do, learning to coexist, and learning to be [1, 2]. Therefore, competency-based curricula enable students to "learn to learn," since they support the development of autonomy, meta-cognition and self-regulation in learning [8], which are essential requirements for human adaptation [6].

K. Galantini Velarde
Architecture Program, Universidad de Lima, Peru
KGALANTI@ulima.edu.pe

Consequently, competency-based curricula can only be effectively implemented through a learning-centered or constructivist pedagogical model, in which students have the main role within the training process, while professors provide guidance, to achieve shared knowledge construction [9, 10]. This model is based upon interaction, negotiation and collaboration between these two main agents of the t raining process, so that learning may be contextualized to students' everyday experience, and so it may be useful for the interpretation of the environment in which they are immersed [9, 10, 11].

In this context, research-based learning (RBL) stands out as an active methodology, framed upon the learning-centered model, that encourages student participation towards knowledge building. RBL is characterized by being directed and guided by a professor, and by being conducted by subjects in training [12]. RBL is based on the promotion of scientific knowledge since students are intended to propose solutions to everyday problems of the society [13]. Therefore, it is a main resource to potentiate LL. RBL requires using interactive learning methods, such as peer learning, flipped classroom, collaborative learning, group discussion, among others, so that knowledge can be collaboratively built [14].

Within higher education institutions, RBL may also be identified as undergraduate research. Undergraduate research is the type of research in which monitoring and assessment are provided by the professors, as part of their teaching roles, and the research agents are active subjects in training [15]. Undergraduate research experiences enable students to come across real challenges within their discipline through a contextualized approach [16]. Thus, a high-impact experiential learning is promoted [17]. Furthermore, they provide better understanding of discipline-specific content [18]. As a result, undergraduate research experiences have been integrated, throughout the curriculum, as part of the training process of professionals of different fields [19, 20, 21].

This integration has been boosted by the increased attention given to the role of research upon university rankings, which has made faculty reflect upon the importance of promoting a research culture within the academy [22]. Research culture can be defined as an environment of interpersonal encouragement and collaboration, where colleagues demonstrate shared affinity about the value of research [23]. Thus, to promote a research culture along the undergraduate competency-based curriculum, research competencies must be developed and reinforced.

Precisely, research competencies provide students with tools to apprehend new information upon a critical sense and based on intellectual curiosity [24, 25]. Through a set of activities that they must develop, such as conducting observations, proposing questions, examining information, planning, developing and applying tools to collect information, analyzing and interpreting data, drawing conclusions, suggesting solutions, discussing explanations, and communicating results, they build knowledge upon real-life problem-solving within their professional context [8]. Moreover, there is evidence about improving learning outcomes through the development of research competencies in various disciplines, such as humanities, health sciences, engineering, among others [19, 26, 27].

However, there is still a gap to be covered by literature about the perception that students have upon the promotion of undergraduate research culture and the role of research for LL. Furthermore, there is few evidence about the activities that are developed by students upon this subject. Even though they may not be aware of it, since they ignore the learning theories behind these principles, students value the benefits that undergraduate research experiences imply for their professional training [25, 28, 29]. Additionally, the panorama of accelerated consumption of global resources highlights the need for new professionals committed to a culture of responsible research promoting the compliance of the Sustainable Development Goals (SDGs) among students [30, 31, 32]. Thus, the development of competencies is an important task within the training processes, since they represent an approach to LL, which is set to ensure continuous improvement within professional performance [33].

Hence, students' motivation towards research is supported through research culture, while highlighting its relevance for learning [34]. In this line, this research shows a case study within an undergraduate engineering program from a Peruvian higher education institution. The program is focused on promoting a research culture through progressively developing and reinforcing research competencies, while strengthening the learning- centered pedagogical model [13]. This program is supported by

didactical tools, so that student learning is encouraged and learning outcomes are improved [35]. One of these didactical tools are student organizations, student groups supported by peer learning.

Thus, the present research seeks to explore undergraduate engineering students' perceptions about the influence of student organizations for the promotion of undergraduate research culture. The students are members of student organizations. This study recognizes the support that these organizations provide to research experiences, and their contribution to the development and reinforcement of research competencies [7]. The following question is proposed: What is the relationship between peer learning, student organizations and the promotion of undergraduate research culture?

2. Conceptual Frameworks

2.1. Peer learning

Peer learning is defined as a two-way reciprocal interactive learning method that represents mutual benefit for the ones involved through the sharing of knowledge, ideas and experiences [36, 37]. Peer learning can be considered as a strategy within the engineering training processes, as it facilitates the understanding of discipline-specific content and promotes debate upon students. Consequently, it allowscognitive processes related to the organization of ideas and concepts [38]. Peer learning occurs amongtwo people whose academic status is similar, and whodo not have a teaching role, even though the peers involved might have experience or expertise in a particular field. Hence, the roles of the teacher and thestudent are undefined and may shift during the learning experience [39]. Moreover, peer learning can take place in a formal or informal learning environment, depending on if the training scenarios are previously designed. In fact, even though formal learning environments come under the purview of the university, much of peer learning occurs informally, without faculty involvement [39, 40, 41].

Peer learning is used to support students, potentiate their academic engagement, and foster their general success within higher education [42]. Additionally, its use has expanded beyond the academic field, towards the development of social skills, integration into university life, leadership, and employability [43]. In fact, peer learning environments have brought benefits that are often lacking in traditional university classrooms and that contribute to personal improvement, such as good study habits, motivation, commitment to the program, and confidence in students' own skills [44, 45]. It can also positively influence students' psychological well-being, through the development of self-regulation and self-efficacy [45, 46, 47, 48]. Therefore, peer learning provides opportunities for student groups to learn from each other and grow together [36, 44].

Within the context of research, peer learning is approached as collaboration between people who share methodological approaches and research interests. This collaboration enables internal research mentoring between peers, the standardization on the quality of the research argument, the creation of research networks, the participation in seminars alongside academics, among others [49, 50]. Furthermore, when focusing on undergraduate students, peer learning has been proven to enhance academic writing skills when conducting research, by using appropriate linguistic forms and increasing grammatical knowledge. It also increases students' confidence to ask questions and give constructive feedback, which allow them to write more objectively [51]. Moreover, peer learning contributes to students' higher level of engagement with their research projects, helping them to achieve positive outcomes because of the interactions held [52]. Finally, evidence also suggests that reflective thinking linked to students' professional performance is also cultivated through peer learning [53].

In the case of engineering programs, where it is well known that the base courses involving topics as mathematics, physics, and chemistry are seen as challenging, peer learning must be encouraged to promote support between students [54]. In fact, among the student community, these courses may cause feelings such as distress, anxiety and stress, which ultimately can lead to undergraduate dropouts [55]. Therefore, peer learning should be encouraged, as it might contribute to mitigate this negative scenario, a major concern upon the higher education context.

Nevertheless, parallel to the strengths of peer learning, some authors report improvement opportunities of this learning method. An example is the focus of the debates, which can be based on the distorted opinions of the parties involved, given the absence of a teacher or expert on the subject, leading to mistaken interpretations [56]. In addition, the

generation of roles among students within collaborative learning exercises does not always work well for all participants, since it can lead to hierarchical differences that may disturb some students [56, 57].

2.2.Student organizations

Among the alternatives to encourage research culture within engineering programs, student organizations are highlighted. These organizations are extracurricular spaces dedicated to debate, peer learning and innovation activities upon professional engineering issues, in which students have common interest [58]. Student organizations, composed by groups of students, are managed as autonomous non-profit organizations. Participation in them is free and voluntary; however, it demands a commitment from its members in terms of time and dedication.

Within these organizations, students play different roles, such as president, coordinator, manager, among others. The designation of these roles follows a meritocracy, and coordinators are appointed to be mediators among the dialogic processes in which knowledge is built between members. The commitments of these coordinators also include proposing, planning and promoting activities according to the group interests, always keeping democratic principles in all the decisions made. A natural exchange of efforts is established between coordinators and members of the organizations, creating a synergy that results in experiences in the art of collaborative learning [45, 58, 59].

Thus, student organizations contribute to promote a research culture, since they encourage peer learning and seek to initiate students in critical thinking. In the case study which this research belongs to, they also allow putting into practice research competencies, which are gradually acquired throughout the curriculum [7]. Group training in research is encouraged, which also involves exercising generic competencies such as teamwork and effective communication [60], which are needed for satisfactory interactions among students [58, 61]. Ultimately, this spectrum of competencies developed and deployed within student organizations increase the opportunities of mobility, employability and networking for the future professionals, as these competencies are the most highly demanded by organizations since they permit greater adaptability to change and a better predisposition for LL [1, 62].

3. Materials And Methods

3.1. Context

This study was carried out on an undergraduate engineering program within a Peruvian private higher education institution. This program is characterized by the design and implementation of a methodology, the Gradual Implementation Research Competencies (GIRC) Program, which allows students to develop and reinforce research competencies gradually and transversally. Furthermore, the GIRC Program was developed within an undergraduate research culture framework [7]. The GIRC Program corresponds to the institution's vision, which focuses on generating high impact research to promote sustainable development [63].

Within context, the GIRC Program encourages different initiatives that support the development and reinforcement of research competencies [7], such as Research Expo [64] and student organizations. The latter create a proper environment to promote undergraduate research culture as, within them, support is given to and by students, in the form of peer learning.

3.2. Design and participants

Regarding the universe and sample, to establish the relationship between peer learning and undergraduate research culture within student organizations and student perceptions about it, these two have matched in this study. Certainly, this research has been developed within an engineering program that was launched in 2017; therefore, the students' community who belong to the student organizations is still into consolidation, and these organizations are expected to attract more members in the upcoming years. The study focuses solely on the student population that is part of student organizations, it should be noted that participation in them is voluntary, based on the discipline-specific interests of each participant.

Accordingly, the student sample is non-probabilistic, particularly judgment sampling was applied. The sample was chosen based upon students' involvement on students' organizations which, at the same time, are part of the GIRC Program [7].

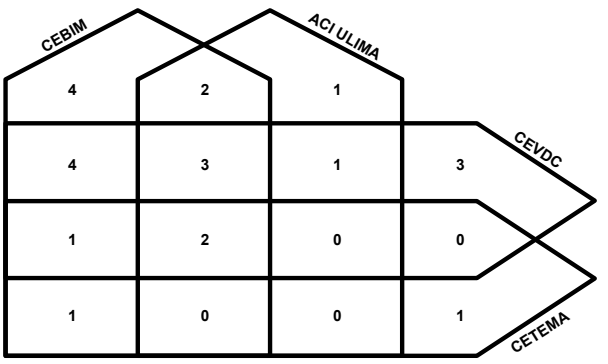
About the student organizations, the engineering program has four (4): *Círculo de estudios* Building Building Information Modeling (CEBIM), *Círculo de estudios de tecnología de los materiales*

(CETEMA), American Concrete Institute *Universidad de Lima* (ACI Ulima), and *Círculo de estudios* Virtual Design and Construction (CEVDC). The approach of these student organizations includes a variety of topics regarding the engineering and construction field. This study focuses on those members of the student organizations who are currently in the final year of the curriculum, where they develop a research proposal, as their final degree project [64]. The universe of this study, which matches the sample, is 23 students, which are distributed among the mentioned organizations, as shown in Table 1. It should be noted that some students are involved in more than one student organization, as seen in Figure 1.

Table 1: Universe distribution according to the student organizations.

Student organization	Number of students enrolled
CEBIM	17
CETEMA	5
ACI ULima	9
CEVDC	14

Fig. 1: Universe distribution according to the student organizations.



3.3. Data collection and analysis

The intention of introducing research culture to undergraduate students seeks to expose them to LL, so that they can learn to identify research challenges throughout the development of their courses of the curriculum. In that way, gradually, and making use of the tools proposed by the GIRC Program, research competencies may be developed throughout the training program [7].

In this order of ideas, at the end of the training program, the research proposals that have the potential to be published as indexed research papers have the endorsement of professors, who are experts in the discipline-specific content and act as technical advisors. Methodological advice is simultaneously provided to students too. Table 2 shows the criteria assessed for this research proposals, as well as the expected description for each one.

Table 2: Criteria for the assessment of research proposal with the potential for publication.

Criteria	Description
Title, summary and abstract	The title, summary and keywords are informative, concise, relevant, related to the study topic, and provide sufficient information about the problem statement and conclusions.
Problem statement and purpose of the study	The problem statement is clear and articulates the research question(s) with its purpose, in a coherent manner, with key data, while contextualizing its relevance and pertinence.
Justification	The justification of the study topic explains the reasons why the research is important, based on the identification of the contributions to society and its relationship with the SDGs.
Scope and limitations	The scope corresponds to the proposed research question(s), and the limitations contribute to the precise delimitation of the study topic.
Objectives	The objectives respond to the problem statement, maintaining a logical sequence for the development of the research.
Hypothesis	The hypothesis(es) presents an answer to the proposed research question(s), and is(are) susceptible of being verified, after a process of observation, analysis and experimentation.
State of the art	The state of the art addresses the problem statement with a chronological order and the information was obtained from primary, current, reliable and relevant sources.
Theoretical framework	The theoretical framework articulates definitions, concepts, norms, and guides regarding the study topic, while maintaining a close relationship with the proposed objectives, which allows establishing the theorical basis behind the phenomenon studied.
Methodology	The proposed methodology is clear and allows to achieve the stated objectives, based on a specific design, collection and analysis methods proposal, and a schedule and budget consistent with the problem statement.
References and citation	References and citation are appropriate to the study topic and up to date. These are properly cited following APA criteria.
Writing mechanisms	The composition is free of grammatical, spelling and punctuation errors.
Presentation	The format complies with all formal guidelines provided.

Students' intention to develop their final degree project as a research paper or thesis was measured through a dichotomous question. Their perception about the influence of student organizations in the promotion of undergraduate research culture and its overall impact on academic performance was measured through a questionnaire with a 5-point Likert scale. The values for this questionnaire went from 1, 'strongly disagree', to 5, 'strongly agree'. For studying the relation between peer learning and undergraduate research culture, four (4) questions were developed. For analyzing the relation between peer learning and academic performance, five (5) questions were proposed. The instrument was specifically designed for the context of this research.

Table 3 presents the ten (10) questions of the developed instrument. In addition, data have been collected on the continuity of participation of members of student organizations throughout the

years of their studies. Information was collected from all senior year students who are developing their final degree project, to assess their overall intention of developing it as a thesis or as a research paper.

The selected factors shown in Table 3 were established in accordance with the strategic plan of the higher education institution to which this case study belongs to, as its mission focuses on the development of high impact research, considering it a fundamental issue for university international world rankings [22]. Finally, information was properly coded for data processing using Microsoft Excel, as suggested by the literature [65].

Table 3: Questions of the developed instrument.

Factor	Nº	Question
Dichotomous question	-	Do you intend to develop your final degree project as a research paper or a traditional thesis?
Relation between peer learning and undergraduate research culture	1	Do you consider that research is encouraged within the student organizations?
	2	Do you consider that the activities carried out in the student organizations have motivated you to pursue a research line?
	3	Do you consider that in the student organizations you find the necessary support to start a research project?
	4	Do you consider that research is an important factor for your professional development?
Relation between peer learning and academic performance	5	Do you consider that the activities carried out in the student organizations have reinforced your knowledge on discipline-specific content?
	6	Do you consider that the activities carried out in the student organizations have contributed to improve your academic performance?
	7	Do you consider that the activities carried out in the student organizations have contributed to the development of your final degree project?
	8	Do you consider that the activities carried out in the student organizations have enhanced your abilities to propose solutions to the challenges of your profession?
	9	Do you consider that the activities carried out in the student organizations have provided you with tools to enhance your professional and personal growth?

4. Results

Figure 2 shows the results for the nine Likert scale questions. On the one hand, it is observed that, overall, students believe that student organizations have a positive effect on the development and promotion of undergraduate research culture. In fact, 52% strongly agree that research is encouraged within student organizations, while 39% agree with this statement. Moreover, 78% (35% 'strongly agree', 43% 'agree') think that the activities carried out within these organizations have motivated them to pursue a research line. Additionally, 79% (22% 'strongly agree', 57 % ' agree') consider that student organizations provide the necessary support to start a research project. Finally, 87% (52% 'strongly agree', 35% 'agree') consider research important for their professional development.

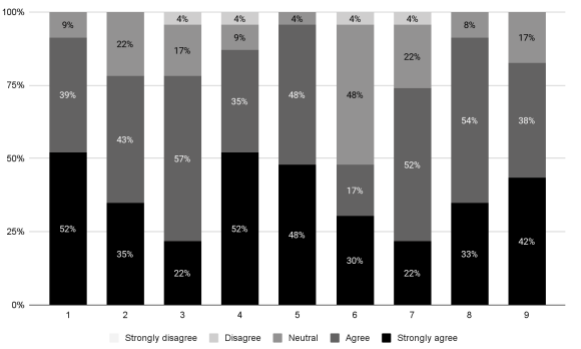


Fig. 2: Obtained results for the 5-point Likert scale questions of the developed instrument.

On the other hand, Figure 2 reveals that 96% students consider (48% 'strongly agree', 48% 'agree') that the activities carried out within student organizations have reinforced their knowledge on discipline-specific content. Additionally, 74% (22% 'strongly agree', 52% 'agree') think that these activities have contributed to the development of their final degree project, while 87% (33% 'strongly agree', 54% 'agree') that they have enhanced their abilities to propose solutions to the challenges of their profession. Furthermore, 80% (42% 'strongly agree', 38% 'agree') consider that the activities have provided them with tools to enhance professional and personal growth. However, only 47% (30% 'strongly agree', 17% 'agree') feel that they have contributed to improve their academic performance.

Figure 3 shows the trend of student participation in student organizations throughout the years of the curriculum. It is noted that students are enrolled in student organizations mostly on the fourth year of the curriculum. Finally, Figure 4, shows the influence of student organizations in students' decision to develop a research paper as a final degree project. In fact, of the total of final degree projects being developed as a research paper, 71,88% correspond to students who are members of student organizations, and only 28,13% correspond to students that are not.

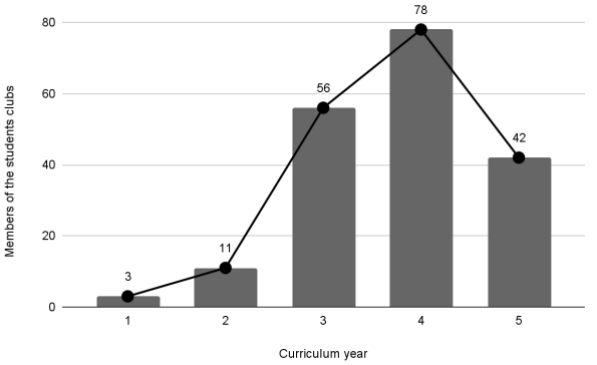


Fig. 3: Members of the student organizations by curriculum year.

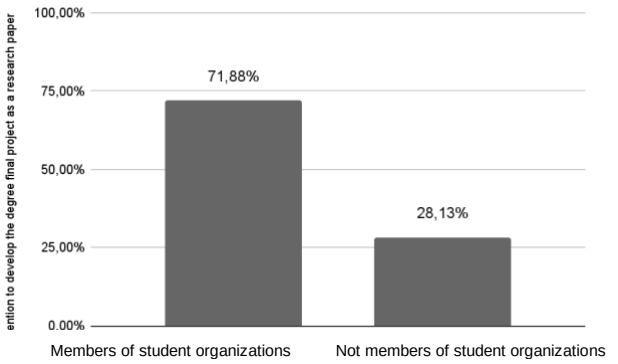


Fig. 4: Decision to develop a research paper or thesis as a final degree project.

5. Discussion

Students' participation in student organizations supports the promotion of undergraduate research culture within an engineering program. Figure 3 reveals two (2) tendencies regarding students' involvement in these organizations. As engineering students move on with their studies throughout the curriculum, they tend to enroll more in these, consolidating their commitment with their professional training [61, 66, 67]. This positively increasing tendency corresponds to the first four years of the curriculum. Then, during the fifth and final year, the number of active members in student organizations decreases, as students tend to be more focused in developing their internships, as reported by literature [68, 69].

Moreover, student organizations can support the development and reinforcement of research competencies. It can be affirmed that, according to students' perceptions, these organizations are an effective tool to promote undergraduate research culture. In fact, 91% perceive research is encouraged and supported within them, since these are spaces in which students share common interests, such as the affinity for developing research [58]. Hence, 78% of the students think that the activities carried out within student organizations have motivated them to pursue a research line, probably in accordance with their peers' preferences, as peer learning implies people who share methodological approaches and interests about research [49, 50].

This overall scenario promotes a positive perception upon research, which is supported by the peer learning activities within the student organizations [39, 40, 41]. This may be the reason why 78% of the surveyed students consider that these organizations provide the necessary support to start a research project, as peer learning enables mentoring between students [49, 50]. In addition, the interactions held among students allow shared knowledge building, when they are mediated by a professor [9, 10, 11].

In this line, peer learning contributes to the development of higher levels of motivation and confidence in students' own skills [44] upon research. Furthermore, learning from the other students may increase the positive perception and provide a better willingness upon it [36, 44], as well as improve its outcomes [52]. At the same time, this promotes positive student beliefs about the value of research, which explains why 87% of the surveyed students consider it an important factor for their professional development and student achievement [70].

Regarding students' perception about their overall academic performance, 96% think the activities carried out within the student organizations have reinforced their knowledge on discipline-specific content, as these spaces involve reflecting upon engineering issues [58]. Moreover, since peer learning within student organizations encourages the practice of social and critical skills [43], which are necessary to develop generic competencies and enable LL, students believe that they enhance their abilities to propose solutions to the everyday challenges of their profession.

Furthermore, 79% of the surveyed students consider that the activities performed within student organizations have provided them with tools to enhance professional and personal growth, as peer learning contributes to personal improvement [44] and promotes self-regulation and self-efficacy [46, 47, 48]. However, less than half think that student organizations have contributed to improve their academic performance, probably because being part of these organizations means dedicating extra study

time to develop the tasks which are committed to them, which may imply splitting the time among these responsibilities and the ones regarding the courses of the curriculum.

Finally, regarding students' intention to develop their final degree project as a research paper or thesis, as shown in Figure 4, it can be observed that student organizations have had a positive impact on the intention to develop a research paper, since 71,88% of the total number of research papers are developed by students who are members of these organizations. Moreover, 73% of the surveyed students think that student organizations have contributed to the development of their final degree project, which may be a research paper. A relation between student organizations with the promotion of research experiences and peer learning may be observed, which leads to looking at student organizations as alternative routes for the promotion of undergraduate research culture.

4.1. Limitations and future research

The findings should be perceived considering the following limitations: first, the study explores the promotion of undergraduate research culture within student organizations based on students' perceptions, a further step of the study should imply applying the designed instrument on professors, to contrast their perceptions. Second, the study only measured students' intention to develop their final degree project as a research paper that should be published in indexed journals or proceedings, and it would be recommendable to monitor and follow up the submission process, to evaluate the final results. Third, it would be valuable to apply the instrument to bigger samples including students of each of the five years of the curriculum, also with an international approach, to widen the scope of the study.

Future works may also study the influence of student organizations on the development and reinforcement of research competencies on students, in accordance with a competency-based curriculum. Additionally, they may analyze the impact of other interactive methods corresponding to the learning-centered pedagogical model, such as flipped classroom, collaborative learning or group discussion, throughout the competency-training process.

4.2. Implications for practice

Student organizations can be seen as the first step towards the formation and consolidation of research groups with defined areas and lines within the engineering field. As undergraduate research is promoted within them, they support the training of future professionals who are committed to finding applied solutions to the challenges of their environment. Moreover, enrollment in student organizations may play an important role in the production of high- impact research at the undergraduate level, with potential to be published as papers in international indexed journals or proceedings.

6. Conclusions

This study offered an insight about the relationship between student organizations and the promotion of undergraduate research culture within an engineering program. It was revealed that students' enrollment in these organizations has a direct and positive impact in the promotion of undergraduate research culture. In fact, the active participation of undergraduate students in student organizations increases in 44% students' intention to develop their final degree project as research paper, during their last year of studies.

Through the applied survey, it was possible to quantify students' perceptions upon the activities developed within student organizations, and their influence on undergraduate research culture. Certainly, 91% of the surveyed students think that research is encouraged within student organizations. Moreover, 78% perceive that these organizations have motivated them to pursue a research line and have provided them with the necessary support to start research. Furthermore, 86,95% have begun to consider research an important factor for their professional development, in accordance with LL.

Finally, peer learning is a key method that enables putting into practice the learning-centered pedagogical model, which allows promoting undergraduate research. Hence, peer learning may contribute to the development and reinforcement of research competencies within an engineering program.

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