FOSTERING SCIENTIFIC RESEARCH IN STUDENTS OF TECHNICAL DEGREES: AN ASSESSMENT AND CONTINUATION

M. Galiana Martínez[1], L. Seguí Gil[2]

[1]Departamento STEAM, Escuela de Ciencias, Ingeniería y Diseño, Universidad Europea de Valencia (SPAIN)
[2]Departamento de Tecnología de Alimentos. Escuela Técnica Superior de Ingeniería Agronómica y del Medio Natural, Universitat Politècnica de Valencia (SPAIN)

Abstract

At present, the industry demands highly qualified professionals, a fact which is of special relevance in technical careers. However, several studies have reported that pursuing doctoral studies is not among the main objectives of first years STEM students. On the other hand, Challenge Based Learning (CBL) has arisen as a useful methodology to provide close to real environments or projects along which specific and generic competences are put into practice and therefore developed. Considering the previous, the present contribution deals with the implementation of a CBL approach in first-year STEM courses with two main objectives: to foster scientific vocation in 1st-year students of technical degrees and to develop and improve transversal and professional competences.

This CBL was performed during both semesters of the academic year 2021/2022. A total of 79 students of 1st year of different technical degrees (Data Science, Physics, and Industrial Engineering) were involved in the project. Students worked in groups of 3 to develop two challenges in which they had to prepare a scientific paper and scientific poster. Both contributions were presented in different formats: the paper was screencasted and the poster was presented onsite in the classroom. Rubrics were used for the evaluation and co-evaluation of these activities. Students' opinion on the activity undergone was gathered through a survey to generate indicators about their perception and satisfaction with the CBL approach.

The most relevant findings were that more than 90% of the participants were interested in research issues; more than 70% enjoyed doing the CBL proposed, and more than 70% claimed to be proud of their work. Besides, more than 90% of the students would like to study research-related issues more in-depth in future courses, and more than 50% showed an intention to pursue a PhD after finishing their degrees.

The results of the present work evidenced that CBL approaches bring magnificent learning opportunities to students. CBL is revealed as a very valuable strategy towards the development of professional and generic competences, which might be crucial in facing subsequent courses and future professional life. In addition, the impact of the CBL approach in fostering the scientific vocation of students has been evidenced. These good indicators have encouraged the authors to continue this line in future courses by coordinating with other lecturers to define a common project involving students of subsequent years. It is expected that the outcomes of these challenges will be analyzed to evaluate the acquisition of competences as well as to track scientific vocation.

Keywords: Challenge-based learning, competence development, student centred approaches, active learning, real contexts.

1 INTRODUCTION

PhD studies offer specialized learning and advantages from an academic and professional development perspective [1, 2, 3]. However, in spite of the industry demanding more specialized workers, pursuing doctoral studies is not among the main objectives of STEM students when accessing the University [4,5]. It has been reported that science & engineering PhD students lose interest in an academic career over the course of graduate training [6]. On the other hand, Ruchina et al [3] discussed that research experiences and skills development are crucial for students at any level of education and can benefit them from their personal and labour perspectives.

In this context, Challenge Based Learning (CBL) is an interesting active learning methodology to be tested, since it is based on experience and competence development through a process which requires an in-depth approach. It provides a framework for learning while solving real-life or simulated situations. CBL is a collaborative learning experience which uses a multidisciplinary approach in which all the agents involved (students, teachers and, in some cases, stakeholders) work together, and propose

solutions to real or simulated situations or challenges [7, 8]. CBL approaches may provide significant learning and be a valuable strategy to develop a series of transversal and professional competences. Through CBL, students drive their own learning through inquiry and collaborative work, facing challenges that require deep applied knowledge [9].

In line with the research developed in other fields [10], the main objective of the present work was to foster scientific research vocation in first-year STEM students, through an experience based on a Challenge Based Learning Approach (CBL). Specific objectives of the present proposal were: (1) Perform a previous analysis on the opinion and knowledge of first-year students about PhD and research career; (2) Undergo an experience based on CBL contributing to the awareness of research careers and foster vocations; and (3) Evaluate the impact of this experience on the opinion and knowledge of students. Finally, as an additional objective (4), the development and acquisition of transversal and professional competences were planned.

2 METHODOLOGY

The experience was conducted during the academic year 2021-22, in the School of Science, Engineering and Design of the Universidad Europea de Valencia (UEV). Students participating were taking 1st year of the Degree in Data Science, Degree in Industrial Organization and Physics Degree (79 students). The courses involved in the project were Mathematical Analysis (1st semester), Lineal Algebra and Basic Experimental Techniques (2nd semester).

The challenge consisted in preparing two contributions to a simulated scientific congress: writing a scientific paper was the challenge chosen for the 1st semester, whereas designing and defending a poster was the one proposed in the 2nd semester. The activity was planned in different steps, as follows: a preliminary questionnaire was designed and answered by students before developing the CBL project; several onsite sessions of guided work were planned, and finally, a final questionnaire was presented to students after having completed the CBL.

During guided sessions students were provided information and trained so that they were able to prepare and present the contributions successfully. Contents of these sessions were, for instance: what's does a scientific congress consist of?; types of scientific contributions; scientific journals and their impact indexes; or, retrieving scientific information from specialized databases. Different modalities of contributions presentations and defense were deliberately planned: the paper was presented by means of a recorded screencast, and the poster was presented in an onsite session in the classroom. Papers and posters were assessed by means of specifically designed rubrics; in addition, posters were co-evaluated by classmates. All deliverables contributed to the final score of the course. A summary of the activities planned for the CBL implemented in the courses involved is presented in Figure 1.

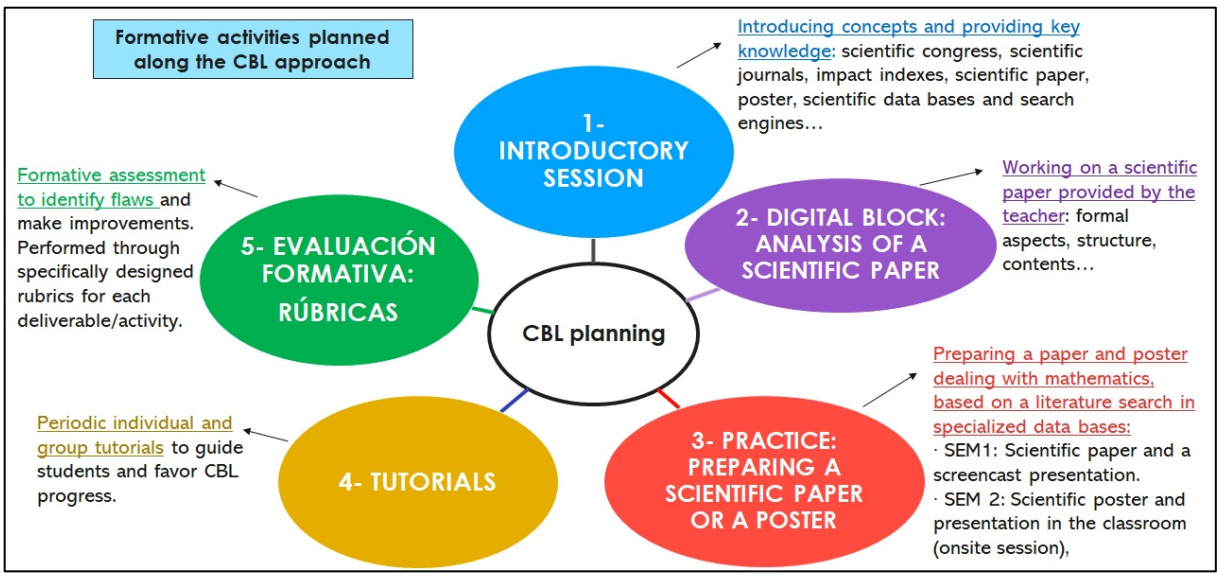


Figure 1. Summary of formative activities planned along the CBL approach.

As for questionnaires, students were given a preliminary questionnaire which was formulated with the aim of evaluating their knowledge of research issues. The questionnaire was prepared and shared with students through Google Forms, and they were given some time in the classroom to answer the questionnaire online. The satisfaction of students with the activity developed was assessed by means of an online final questionnaire. This second questionnaire was answered outside of the classroom, once the activity and the course had finished. Questionnaires included informed consent for participation in this study. A more detailed description of the questionnaires and rubrics used may be found in a previous contribution [11]. The present paper focuses on the analysis of the answers to the final survey, which are summarized next:

Table 1. Questions answered by students after having completed all CBL activities (final questionnaire).

	Question	***Answer***
Q1	In a 1 to 5 scale, indicate if you have enjoyed the activity proposed: scientific paper.	Likert scale (1. very little – 5. very much)
Q2	In a 1 to 5 scale, indicate if you have enjoyed the activity proposed: scientific poster.	Likert scale (1. very little – 5. very much)
Q3	In a 1 to 5 scale, say if you are satisfied with the final result of the paper you have prepared.	Likert scale (1. very little – 5. very much)
Q4	In a 1 to 5 scale, say if you are satisfied with the final result of the poster you have prepared.	Likert scale (1. very little – 5. very much)
Q5	In a 1 to 5 scale, indicate the difficulty of preparing and writing the paper	Likert scale (1. very easy – 5. very difficult)
Q6	In a 1 to 5 scale, indicate the difficulty of designing and preparing the poster	Likert scale (1. very easy – 5. very difficult)
Q7	Would you like to develop similar activities, related to research issues, during the degree?	Yes / No
Q8	In a 1 to 5 scale, value the amount of new information learned during this course, with respect to developing a research career.	Likert scale (1. very little – 5. very much)
Q9	Would you like to have received more information?	Yes / No
Q10	If the school/university schedules seminars or workshops to learn about research career issues, would you participate?	Yes / No
Q11	In a 1 to 5 scale, value the sentence “The activity has increased my interest in research and developing a research career”.	Likert scale (1. totally disagree – 5. totally agree)
Q12	In a 1 to 5 scale, value the sentence “I would consider completing a PhD after finishing my studies.	Likert scale (1. totally disagree – 5. totally agree)
Q13	Considering developing a career in research, with which sentence do you feel more identified?	I would like to develop a research career to contribute to society I would like to develop a research career since I would like to continue learning I wouldn’t develop a research career since I don’t see a direct application I wouldn’t develop a career in research because of economic reasons (income).

3 RESULTS

Results of the preliminary questionnaire (answered by 49 subjects) were presented in a previous contribution [11]. In the present paper, the impact of the activity on students’ opinions towards research issues as deduced from the final questionnaire is analyzed. The preliminary questionnaire revealed that although most of the students in 1st year ignored essential aspects of research and more than a half think that research is not very well considered in Spain; a significant proportion (more than 50%) could consider the possibility of carrying on a PhD after their studies and a large proportion of them (85%) also considered the possibility of developing a career in research to help society progress and continue learning [11].

During the CBL process, the role of technology was enhanced in several ways. For instance, when corroborating information thanks to using of reliable information sources, or with the proper use of scientific online resources (Google Scholar, Scielo, Redalyc, Research Gate, Eric, Academia, Dialnet). The use of TICs was also essential for the design, preparation a defense of posters by using specific software (Canva, Piktochart, Photoshop) or the use of QR to broaden information. As for competence acquisition, competence development was evidenced along the CBL project. Lecturers registered the impact of this approach in professional and transversal competences such as teamwork, planning and time management, oral and written communication in own and foreign language, autonomous work or critical ability, among others.

As for the student's opinion on the CBL approach and its impact on scientific vocations, the results of the survey answered at the end of the year are plotted in figure 2. In this figure, pie graphs are used to show percentages of subjects selecting one or another answer for each question raised. The survey was answered by 31 subjects.

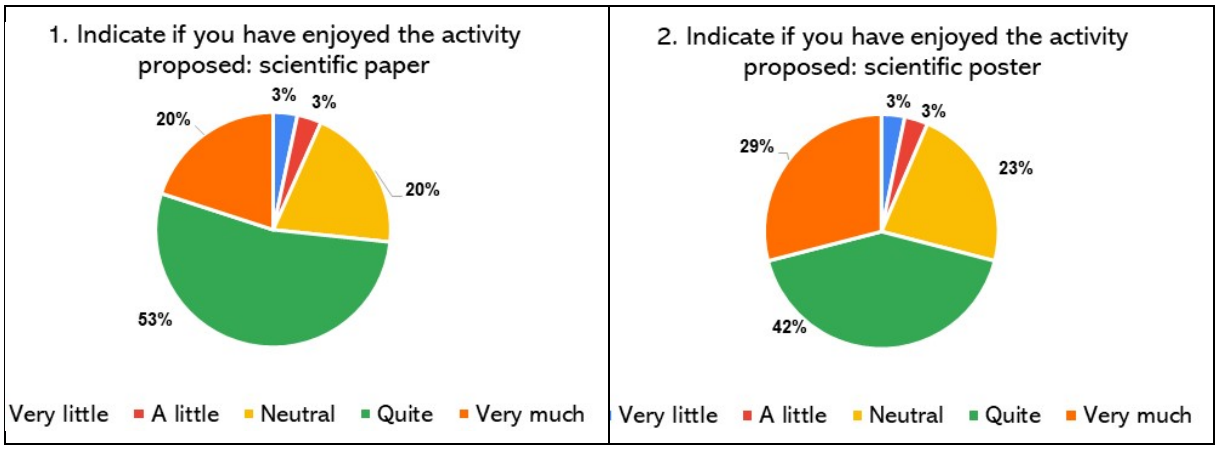
Responses given revealed that most students enjoyed the activity and valued it very positively (Q1 and Q2). As for the scientific paper, more than 70% of the students indicated that they enjoyed quite or very much preparing it; similar results were obtained regarding the poster. In contrast, only an almost negligible percentage (6%) declared to have enjoyed it very little or little. The rest of the participants declared to be neutral.

In line with the previous, satisfaction with the work performed was remarkably high (Q3 and Q4). In fact, almost 90% of the students declared to be quite or very much satisfied with the scientific paper and poster presented, whereas only 3% said to be little satisfied.

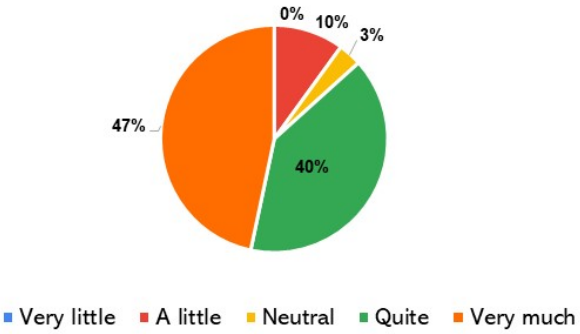
Students did not perceive the activities developed as very difficult (Q5 and Q6); the paper said to be a bit more difficult to prepare than the poster (34% vs. 26%). It needs to be considered that the scientific paper was the activity proposed in the 1st semester and the poster in the 2nd one, when students were more familiar with the methodology and had acquired a higher command of the skills needed. About half of the students declared neutral to this question. Authors believe that, even if students did not consider the contributions very difficult to prepare, they are complex and complete tasks for which students did not dare to qualify them as easy.

Questions 7 to 9 were used to assess the amount of information received during the CBL approach, as well as the interest in receiving more information or participating in workshops on the topic (PhD opportunities, research career) or participating in more activities such as the ones developed in other courses of the degree. According to the results obtained, the vast majority of students (>90%) were interested in developing other CBL approaches during their degrees and would like to go a bit more in-depth with regard to the development of a research career or participate in research-focused workshops.

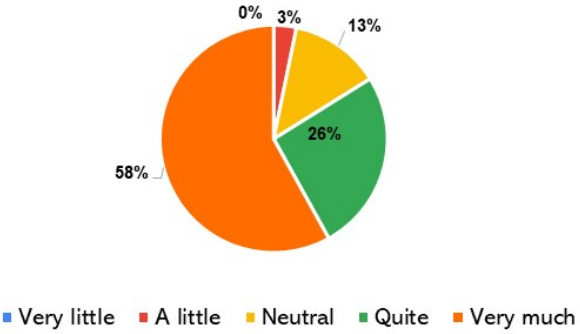
Students declared the activity had a positive impact on their interest in developing a research career (55% agreed or totally agreed) and pursuing a PhD (61% agreed or totally agreed). "To continue learning" seemed to be the main motivation (53%), followed by "to contribute to society" (27%). Only 20% declared not to be willing to develop a career in research due to "low applicability" (13%) and low expected income (7%).



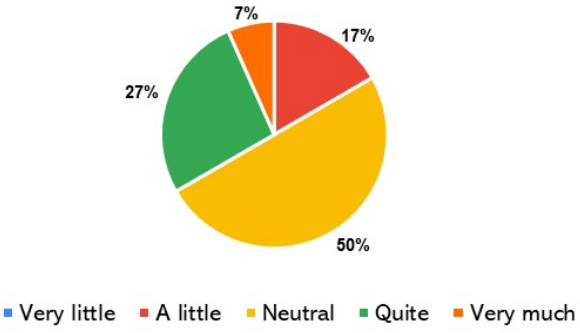
3. Say if you are satisfied with the final result of the paper you have prepared



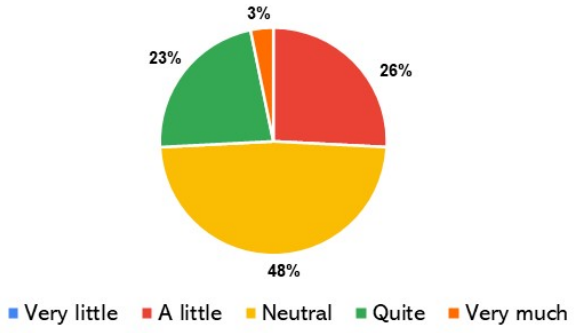
4. Say if you are satisfied with the final result of the poster you have prepared.



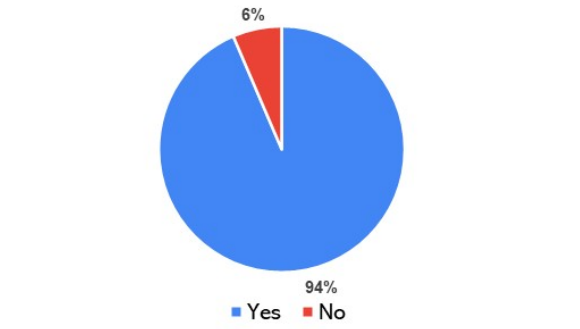
5. Indicate the difficulty of preparing and writing the paper



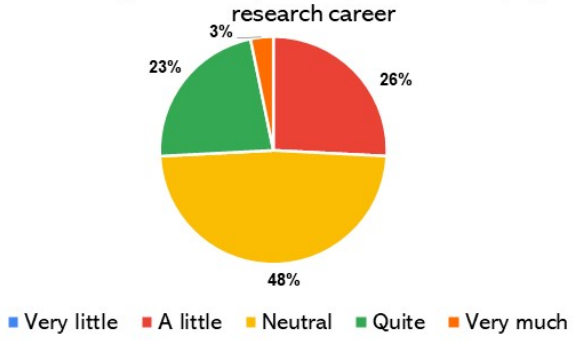
6. Indicate the difficulty of designing and preparing the poster



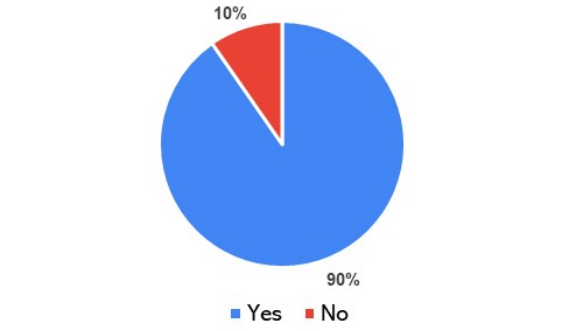
7. Would you like to develop similar activities, related to research issues, during the degree?



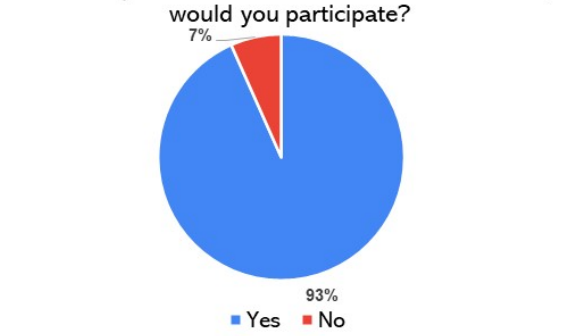
8. Value the amount of new information learned during this course, with respect to developing a research career



9. Would you like to have received more information?



10. If the school/university schedules seminars or workshops to learn about research career issues, would you participate?



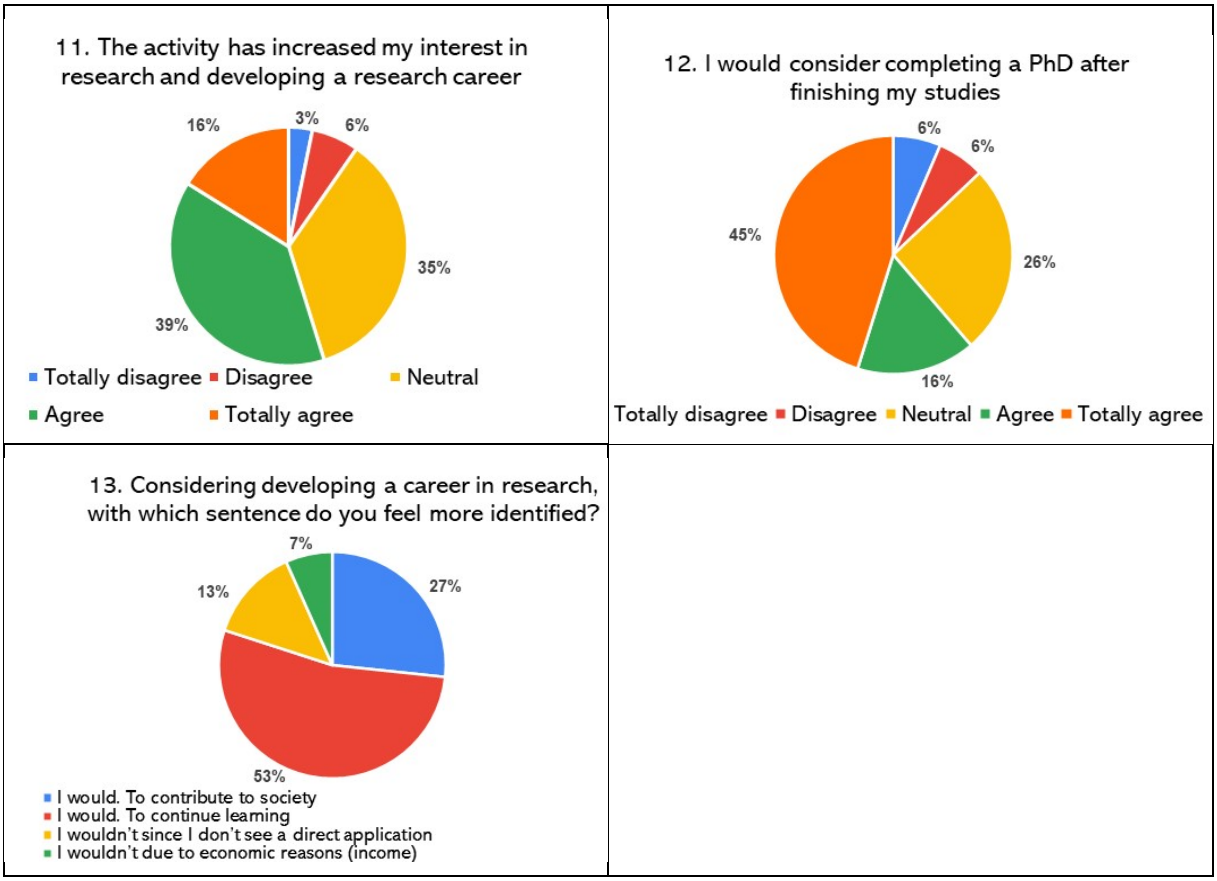


Figure 2. Answers to the final questionnaire.
Values are given in percentage of students over a total of 31 subjects.

4 CONCLUSIONS

The purpose of this activity was not only to foster scientific vocation in 1st-year students but also to provide them with the essential concepts to start understanding the basics of research. Facing close to real-life challenges results in very enriching for students, both for learning content and competence development. CBL approaches bring magnificent opportunities to students, which are not available when performing classical academic works. CBL is also a very valuable strategy towards the development of professional and generic competences, which might be crucial in facing subsequent courses and future professional life.

Results of this work showed that most of the students that took part in this experience were interested in research (>90%). A large part of them enjoyed doing this CBL (>70%) and they felt satisfied with the results achieved (>80%). Moreover, around 90% are willing to explore this field in the next courses. Finally, more than 50% expressed their preference to tackle a PhD after finishing their studies, which is a good indicator of engagement. The main reasons were to continue studying (lifelong learning) and to contribute to society.

Research in technical areas is essential for society progress and development. The good results obtained in this work have encouraged the authors to continue this line in future courses, by coordinating with other lecturers to define a common project involving students of subsequent years. It is expected that the outcomes of these challenges will be analyzed to evaluate the acquisition of competences as well as to track scientific vocation.

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