TEACHING INNOVATION IN ENGINEERING: A STUDENTS AND TEACHERS' LEARNING INTEGRATION PROGRAMME

INNOVACIÓN DOCENTE EN INGENIERÍA: UN PROYECTO INTEGRADOR DE APRENDIZAJES DE ESTUDIANTES Y PROFESORES

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ABSTRACT

This paper presents an experience in teaching innovation whose goal is to improve learning in engineering students and teachers (University of Seville, Spain). This innovation offers students a realistic, professional and updated vision of the contents, allowing them a direct contact with the problems posed by the knowledge and competence inherent to a subject, using facilities and resources at a high-tech research laboratory. It is an assessment-research case study that uses quantitative and qualitative methodologies. The results show improvement in the students' learning processes as well as their high satisfaction; it also highlights the difficulties found. The teachers acknowledge this innovation process as a strategy to learn to teach and create improvements for the program.

Keywords: educational innovation, teaching, engineering, assessment.

RESUMEN

Este trabajo presenta una experiencia de innovación docente cuyo objetivo es mejorar el aprendizaje de alumnos y profesores de ingeniería (Universidad de Sevilla, España). La innovación ofrece a los alumnos una visión realista, profesional y actualizada de los contenidos, permitiéndoles el contacto directo con la problemática del conocimiento y la competencia propios de una materia, usando instalaciones y recursos de un laboratorio de investigación de alto nivel tecnológico. Es un estudio de caso de investigación evaluativa, utilizando metodología cuantitativa y cualitativa. Los resultados indican mejora en los procesos de aprendizaje de los alumnos y su alta satisfacción, señalando también las dificultades encontradas; los profesores, reconocen el proceso de innovación como estrategia para aprender a enseñar y generar mejoras del programa.

Palabras clave: innovación educacional, enseñanza, ingeniería, evaluación.

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This paper presents an Innovation Project of the School of Engineering, developed for the 2011-2012 Innovation and Teacher Improvement Announcement at the University of Seville (US), Spain. As all Innovation Projects, this is triggered by the clear perception of what changes and why these changes are necessary, considering ongoing social transformations (Villa, Escotet & Goñi, 2007). This entails analyzing the needs originated by the teaching context. Then, the interest in participating in and carrying out a teacher Innovation Project for the Strength of Materials and Product Structures course rises from different needs. These needs respond to the degree program at this university and to the state of affairs reflected in the research literature on teacher and engineering students' training:

First, the need to offer new and better training opportunities along the guiding lines of the European Higher Education Area and their skills-based focus allowing future engineers to be efficient and effective in the development of their careers, as defined at international level (Feisel & Rosa, 2005). These competencies will become regulatory needs (Zabalza, 1987). Therefore, a focus on the acquisition of competencies emphasizes the value of laboratory practices in any of the majors, especially in engineering, to start shaping professional identity in future engineers with a problem-solving teaching approach (Bará, Domingo & Varela, 2011; Huber, 2000), which strengthens student autonomy (Martínez Lirola, 2009). This project specifically refers to the practices we suggest in order to create coherence between the activities the students will have to carry out in the laboratory and the competency-based teaching approach, with an emphasis on the skills and techniques aimed at the competencies established in the program, which can be reached, mostly, in the laboratory (Fry, Ketteridge & Marshall, 2009). Moreover, these practices offer the opportunity to assume responsibilities in the handling and care of equipment and materials. Also, focusing on professional competencies creates favorable situations for students to develop a picture of the possibilities for action within their major (Feisel & Rosa, 2005). Another aim is to increase student motivation and the number of students who pass the course (Vázquez, 2009), adopting the situated learning approach (Lave & Wenger, 1991), since increasing students' learning outcomes is of great concern in different engineering courses. Furthermore, it is central to integrate dominating technological skills into the knowledge era: data collection and reduction, data simulation and acquisition, and information sharing via Internet (Marcelo, 2002; Marín, Reche, & Maldonado, 2013). Now then, analyzing resources in this context, there exist comparative needs (Zabalza 1987): while industrial, aeronautical, and telecommunications engineers, among others, have well-equipped facilities and high-tech laboratories where research projects in collaboration with firms in various sectors are developed; product design and development engineers still have no facilities of their own, with which the University of Seville is planning to provide the School.

Second, we feel the need to evaluate the experimentation with new teaching proposals in order to integrate them into the programs established if they show quality value (Mauri, Coll & Onrubia, 2009) and a positive impact in students' learning (Palazón-Pérez, Gómez-Gallego, Gómez-Gallego & Pérez-Cárceles, 2011).

Third, as novice teachers, we need to learn how to teach based on our own experiences (Bozu, 2010; Knight, 2006), integrating students' different learning strategies for the solution of real problems with the evaluation of the experience (De Miguel, 2003). Here, student satisfaction and involvement in the task, as well as performance in the course should be taken into account. This entails incorporating reflective practice aided by experts in order to build pedagogical knowledge, a teacher training model which facilitates "learning to think, to get to know, to feel and to feel good, and to act as a teacher" (Feiman-Nemser 2008, p. 698). Finally, we have seen that innovation advice is a proven strategy in new teacher training, since they learn to teach with better practices in an intellectual environment that enlightens thought and nourishes it by reflecting on teaching (Fletcher & Mullen, 2012), which has been incorporated in this project. With all this, we want to stress the university teacher training during practice orientation is based on situated learning principles, which we also support for students and which demands authentic practice, collaboration with colleagues and professional advice for the construction of practical knowledge on teaching (Mayor Ruiz, 2003).

Thus, considering that this Innovation Project responds to the students' learning needs —as future Design and Product professionals— and to the teachers' needs as well —as teaching apprentices—, the research problem is defined as the analysis and evaluation of the processes involved in the development of a specific teacher innovation project for teaching-learning improvement. The objectives in both directions are:

1. **For students:** educational objectives integrated into the general and specific competencies are proposed, with emphasis on:
   a) Approaching theoretical knowledge to practice, for reinforcement.
   b) Studying new materials and using the principles of strength of materials.
   c) Developing the following skills: problem-solving, organization and planning, applying knowledge to practice, analysis and synthesis, and critical thinking.
   d) Promoting professional motivation and professional ethics development.
2. **For teachers involved:** this Innovation Project is set out as an opportunity to learn from the educational practice to carry out teaching functions specific to the teaching professional: meaningful action planning, teaching interaction, systematic action analysis, and action and result evaluation of the teaching practice (Estebaranz, Mingorance & Marcelo, 1999). The basic interest of this educational project is to learn how to plan autonomous and collaborative learning activities, and to facilitate this through teacher orientation (Palazón-Pérez et al., 2011).

METHOD

Design

The object of study is the educational Innovation Project. We have used the case study methodology because we consider it to be a very appropriate strategy in teacher training and educational research (Marcelo, Parrilla, Mingorance, Estebaranz, Sánchez & Llinares, 1991). This is a holistic single-case study, as it is a new educational experience in a new subject in a new program with two groups of students. This is also an intrinsic case study (Stake, 1998): We study it for the value it may have *per se* and, therefore, it is descriptive and evaluative. It can also be considered exploratory for the small amount of research that addresses all the aspects of engineer training at university level, as is this case, and for the smaller amount of research in the course itself, although we have studied some partial components in student training (Pérez, García & Sierra, 2013).

Participants

The study was targeted at two groups of students, one in the morning and the other in the afternoon, in the second year of Design and Product Development Engineering, with a total of 74 students, the study population. From them, 32 are female (43.2%) and 42 are male (56.7%). However, since they were voluntary participants in the study, the total amounted to 43, distributed in three groups of 15 students for the first activity (visit). The groups for the second activity included 5 to 7 students. Students formed their own groups, so the composition was mixed.

Two new teachers (with internship experience) developed the program and participated in the action research study.

Assessment

The assessment of this Innovation Program has been carried out according to the Model for Educational Program Evaluation by Pérez Juste (1995). This model includes diverse moments and objects which imply different techniques and the participation of various agents, especially students, and was in accordance with the educational approach we used as basis. We wanted to gain important insight of the value of experience through the triangulation of techniques, subjects and evaluators, considering different criteria:

- **Design Assessment:** Design assessment was performed by members of the Innovation Committee of the University of Seville, based on the quality criteria established in the innovation project invitation: originality, coherence and viability. Its purpose was to determine the intrinsic value or merit of the innovation proposal. Valuation is manifested through approval. Three hundred sixty-six teacher innovation projects were presented, of which 176 (around 47%) were approved. This project was among the selected and financed by the US. It was awarded 33 points from a maximum of 45, and so was among the 36% approved with the highest score.
- **Project Implementation Assessment.** Teachers in charge evaluated the implementation of the project, applying the following criteria: a) student motivation generated and kept throughout activities; b) relation between participation in the direct teaching activity (DTA) and the qualifications obtained in the subject per student in the first invitation, comparing the group of students who participated with that which did not participate; and c) the results analysis, both quantitative and qualitative, of the survey completed by the students who participated in the guided academic activity (GAA) in order to give voice to the subjects, so that their perceptions are understood for improvement proposals (Hamilton & Corbett-Whittier, 2012).
- **Process and Student Results Assessment.** The in-person participation in the activity, the solution of problems posed to the groups, and the individual activity were valued with one point maximum, which was added to the score obtained in the exam. The exam included ten theory questions, six theory-practice items, and the solution of a problem with five subparts addressing multiple topics in the subject.

Thus, we performed a document analysis of the innovation program and the academic transcripts of the students to obtain data on objectives, methodology and performance.

We prepared an *ad hoc* survey with five categories in this innovation program: visit to the technological laboratory, instruction opportunities, relationship between the technical program of the subject and the practice, valuation of individual exercises carried out on the technological platform, valuation of new functional contents. Questions were asked in a simple and precise manner, they are clear for the participating students since they refer explicitly to this innovation; the answers are multiple choice, using the Likert scale. The instrument is capable of collecting data from all students on the same questions. To deepen individual valuation, we asked an open question which collects written qualitative data containing the particular opinions of all students who wish to express their ideas, feelings and suggestions. The survey was elaborated by participating teachers, with the advice of expert teachers in the subject (the research group to which the two teachers involved belong) and the innovation advisor (Professor of Didactics and Curricular Innovation).

Context Description

The Innovation Project, GAA in nature, was proposed as a voluntary activity for the students of the course, which we took into account for the purpose of the course evaluation, considering that an activity becomes relevant to students only when it is graded.

The activity was organized based on the number of participating students and laboratory availability (a technological laboratory which performs analysis for different companies in the aeronautic sector and in which teachers of the subject carry out research activities). Students agreed to the trip that going to the laboratory involved. The time invested in the activities was as follows: The first activity lasted four hours. The second activity lasted approximately one hour. The individual activity took a maximum of one hour per student. Instructions for the activities were given during tutoring hours of the corresponding teachers.

Emphasis should be given to the added value offered by the possibility to use facilities and resources (Zabalza, 2002) of other university centers to achieve these new objectives, as the suggested activity was developed, partly, in the Elasticity and Strength of Materials Laboratory of the Higher Technical School of Engineering, located in an urban district different from the one the Polytechnic School is located at and where this program was being taught. Teachers wished to contribute to equal opportunities in these students' training with regards to other engineering programs.

PROCEDURE

The study methodology is based on triangulation (Hamilton & Corbett-Whittier, 2012), in the manner used in the classic case study: agents, data collection and analysis techniques (both qualitative and quantitative), analysis units and process times. Innovation is a system and we study the totality of the elements implied with different techniques and instruments, according to the nature of the object: plan, implementation, viewpoint of the agents involved –students' perceptions are central– and process and results assessment. In other words, we apply evaluative research techniques.

Given the circumstances of this research project, it is particularly important to analyze the teaching-learning methodological strategies. The project was oriented within two critical lines of US innovation and teacher improvement: the experimentation of new teaching methodologies and the encouragement of diverse manifestations of team work (Bará et al., 2012). The project consists of a GAA in the

Product Design and Development Engineering program of the Polytechnic School of the University of Seville, in the course of Strength of Materials and Product Structures. In this activity we expected to offer students a different view of the contents studied in theory classes –whose contents pose a linear relation of independent units-, to use subject knowledge in the resolution of problems which form a network of meaning (Estebaranz, 2003). We also seek to broaden students' knowledge by studying new materials used in construction, which they would otherwise not study. On the one side, we expected the student to come in contact with the different materials found in structures, emphasizing compounds, which are not object of study in theory classes or in any other subject. On the other side, we expected students to physically observe the different structural typologies which can be found in actual constructions. Furthermore, we saw different construction possibilities for joints from a realistic and practical point of view. We pursued a practical methodology that combined a collective activity with a team activity (Caballero & Garza, 2012; Rebolloso, Ramírez, Gil & Gil, 2008), and finally an individual activity.

This educational process was organized and developed as follows:

1. Collective Activity. A visit to the facilities of the Elasticity and Strength of Materials Laboratory of the Higher Technical School of Engineering, including: a) orientation, b) observation and study of different types of structures and environmental conditions, and c) stress rupture testing: steel, aluminum, carbon fiber / epoxy resin with different fiber orientation. Through this activity, students were able to recognize and distinguish the main mechanical and behavioral properties of these materials.

2. Group Activity. Cooperatively, students analyzed and solved problems related to the study and description of structure typology on an actual structure with the help of an instructional guide: material description, bar types and environmental conditions, test result analysis of the machine curves and the failure in the broken pieces.

3. Individual Activity. On-line, students carried out the activity Problem Solution (bar frame structure) with different materials, presented it on the virtual platform WebCT used for on-line course activities, following the instructional guide: reaction forces, optimal section area, structural displacement and comparison of the results of different materials.

Triangulation, then, assures the operability of the validity criteria in case study research: credibility, comparability and transferability. Thus, we triangulated the resulting data of the document analysis, the academic transcripts, and the quantitative and qualitative data of the student survey. Once the quantitative data were collected, we did a descriptive statistical analysis in terms of frequency and percentage. The qualitative data of the survey and teacher observation were subject to categorical and qualitative content analysis (Denzin & Lincoln, 1998).

RESULTS AND DISCUSSION

We present the case study results, grouped in the following three assessment categories:

- Teacher assessment responds to different questions, always in relation to the objectives of the Innovation Project:

How much interest did the activity generate in students? GAA proposal was made for the class in general. They were invited to participate in an attractive way, starting from the idea of going to a laboratory to break material and observe what happened under certain conditions. This meant a new approach to their work rules. Sixty percent of the students registered in the Product Material and Structure Strength course responded. In order to value the percentage of students voluntarily participating in this innovation activity, we need to consider some situational aspects: this is a course in the fall semester, so this GAA was performed in December, after a mid-term written evaluation aimed at self-evaluating learning acquisition by the students, and evaluating the course progress by teachers. Consequently, this may have been an important influence for a significant number of students (31) to not participate in the course assignments this year and not take the final exam. This means that practically the total number of students in the course who attended classes registered for the GAA.

What was the general performance of students in the course? Of the students registered in the course (74 students), 51% took the exam. If we only consider the grades of the students present (38 students), 42% obtained a passing grade[1] and 11% obtained the qualification "notable". We need to emphasize that more than 50% of the students who attended the course, passed. If we compare these data with the performance criteria established in the Verification Report of Degree Program Quality (Memoria de Verificación de la Calidad de la Titulación), which determines 30% pass as acceptable performance, we observe that performance in this course was 20 % higher than that.

What is the relation between the GAA and the qualifications on the first exam invitation? To analyze the possible connection between participating in the GAA and learning results, we should remember that this course is new, since the major was recently created; therefore, we cannot compare current results with previous years. In Figure 1, we show the results of the qualifications obtained in the first exam invitation, among all students registered in the course and that attended the optional laboratory practice (collective activity).

As we can observe in Figure 1, out of the 43 students participating in this activity, 42% did not take the exam, 16% failed the exam, 33% passed the exam and 9% obtained "notable". It should be taken into account that this was the first time this course was being taught; thus, we cannot compare results with previous years.

Now, if we look at the relationship between the qualifications obtained in the first exam invitation by students who also carried out other project activities (optional laboratory practice (in groups) – online activity (individual)), we can observe the data in Figure 2.

By analyzing the data in Figure 2 thoroughly, we are trying to establish the relation between activity participation and results obtained. A total of 21 students participated in all activities; from them, 10% did not take the exam, 19% failed the exam, 52% passed the exam and 19% obtained "notable". We should point out that although the number of students who participated in all activities (21 students) is lower than the number of students who participated in only one activity (43 students), the percentage of students in the most active group who did not attend was lower than the one who only visited the laboratory: 10% vs 42%, while the percentage of students who failed was practically the same: 16% vs 19%. However, the most interesting results were in the percentage of students who passed: 52.4% vs 32.6% corresponding to the ones who only carried out the first activity. This shows that those students who participated in all activities have a much higher probability of obtaining satisfactory results in the course exam with the complete content program. Another highlight is that all students who obtained “notable” (4 students), participated in all the activities. As already observed in Palazón et al. (2011), active methodology influences results positively.

In Figure 3, we show the number of students in the course who passed in the first exam invitation and their participation or not in the optional laboratory practice. A total of 20 students passed. From them, 90% participated in the optional activity and only 10% of the students who passed did not participate in the GAA.

Thus, it is clear that the results in Figures 1, 2, and 3 show the possible link between the optional activity developed according to the project and the satisfactory results in the course exams, which deal with all contents of the program. Also, comparing the academic transcripts of this course with those of other courses in the first year of the previous academic year (of these same students), we can observe that the percentage of students who took the exam in the first invitation and those who passed the exam increased significantly (from 37% to 51.4% and from 13.75 to 27%, respectively). The data seem to show there is a relation between participating in the GAA and attaining the objectives which influence the learning outcomes of the course this GAA belongs to (a set of innovative activities). However, we also notice a relation between carrying out all the activities and the success in the course qualification. In another study (Justo, Távara, Marín & París, 2013), environmental factors, such as a strike that did not allow the fulfillment of the group work, were proven to influence not only the process but also the results.

- GAA Assessment by Students

Answers to the survey: quantitative data.

We show the general assessment by students through the analysis of the multiple choice answers to the opinion questions asked. A total of 23 students answered the survey which was presented in the virtual platform WebCT, used for the individual online activities of the project. As occurs with the teacher assessment by the

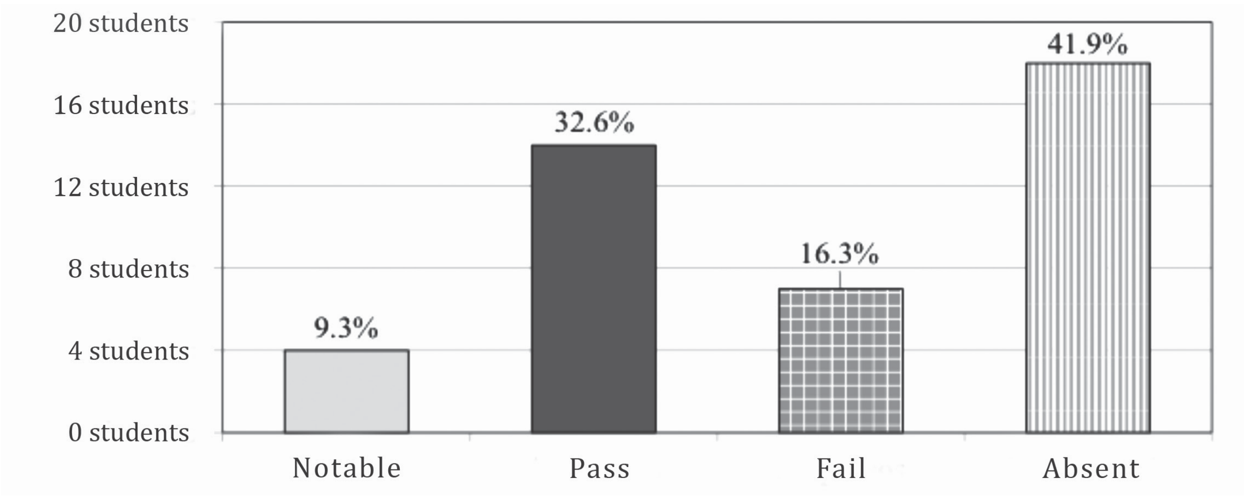

Figure 1. Results of the first exam invitation among the students who attended the optional laboratory practice.

[1] The grading system is as follows: 0-4: fail; 5-6: pass; 7-8: notable; 9: outstanding; 10: honor roll.

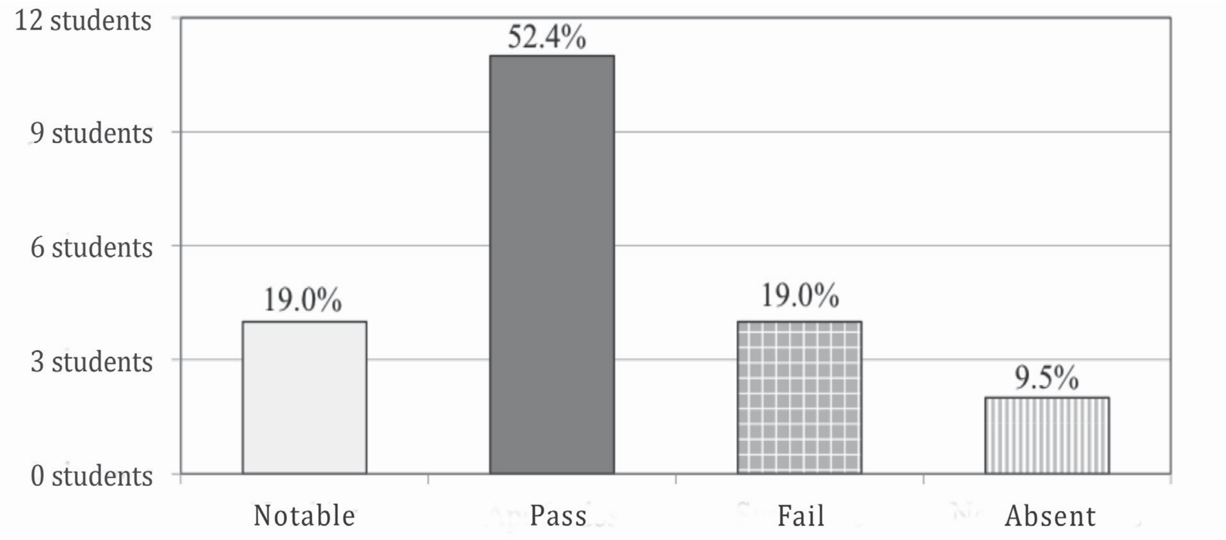

Figure 2. Results of the first exam invitation among students who attended the optional laboratory practice and carried out the online activity.

US, the response to evaluation questionnaires online is always lower. Therefore, we believe that for future surveys, surveys should be applied in class in order to obtain more response. We present the questions, as originally posed, as well as the answers obtained:

1) From a general viewpoint, how did you like the visit? As we can observe in Figure 4, 43% of the students considered they liked the visit and 57% of the students answered they liked it a lot. These results (amounting to 100%, if added) show the great interest generated by the GAA in participating students.

2) From a general viewpoint, do you think the visit was educational? Results show that most students participating in the visit to the laboratory found that it had influenced their learning positively (see Fig. 5).

3) Do you believe that the visit has helped you strengthen some of the concepts taught in the course? Results show that although students liked and found the visit educational, 52.2% identified a relation between these practices and the course contents; a significant percentage (47.8%) did not identify the relation between the visit and the concepts studied in the theory classes of the subject (see Fig. 6).

We consider that the collective activity (observation) and the group activity (problem solving) should have stressed more on such relation because of the great difference between class activities and laboratory tests. We agree with other authors (Pérez et al., 2013; Serrano, Pérez, Biel, Fernández & Hernández, 2013) in that a closer follow-up of the group may contribute to its success and results.

4) Do you consider that the WebCT exercises in relation to the visit helped you to study the subject? Most students considered that doing the exercises somehow helped them to reinforce the concepts taught in class (Fig. 7).

As teachers, besides, we appreciate that integrating information and communication technologies in teacher innovation processes renders personal learning time more flexible and facilitates autonomy in the process (Marcelo, 2002), which was one of the objectives in this Innovation Project (DTA).

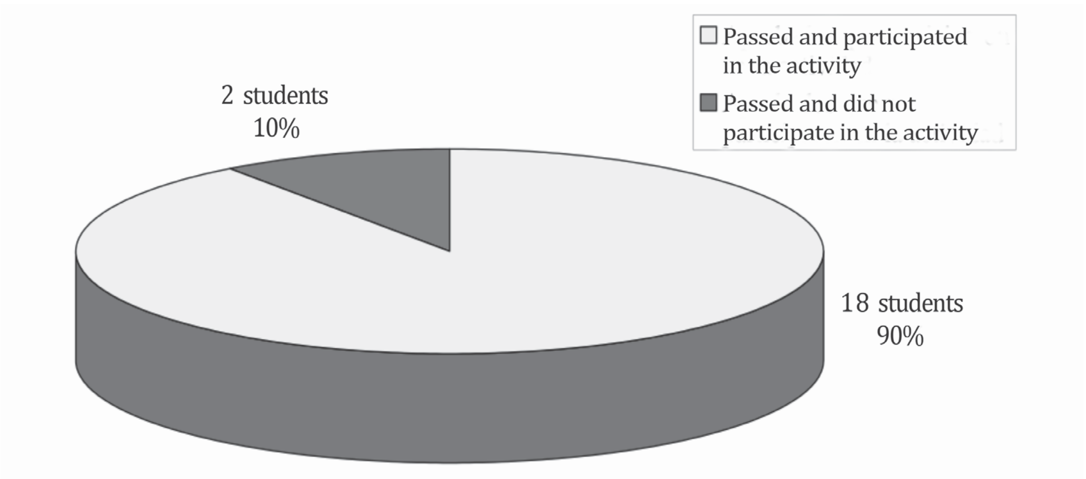

Figure 3. Number of students who passed and participated in the optional laboratory practice.

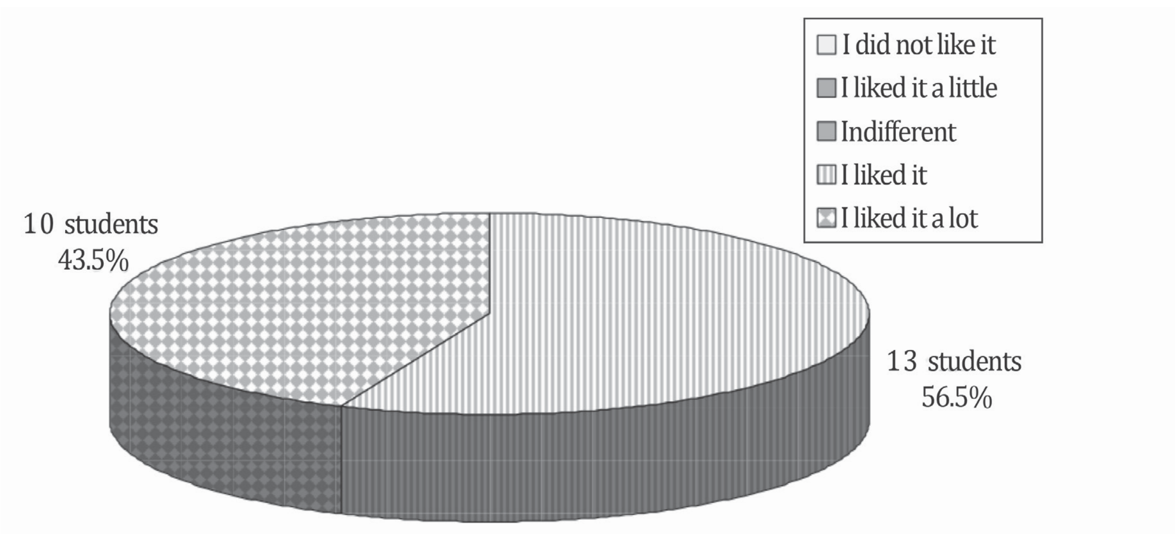

Figure 4. Results of question 1 in the survey: From a general viewpoint, how did you like.

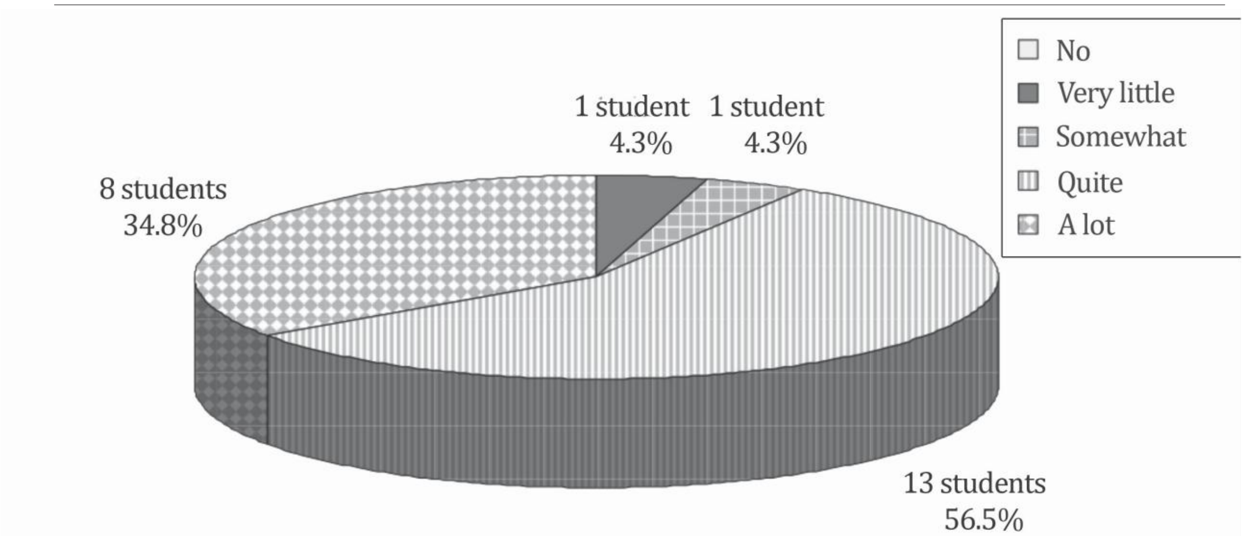

Figure 5. Results of question 2 in the survey: From a general viewpoint, do you think the visit was educational?

5) Do you believe the content related to composite material (not considered in the course) is relevant to your training? The quite positive answer reveals the interest shown by 96% of the students in new concepts not directly related to the course, but with their future careers. These concepts were taught thanks to this GAA (Fig. 8)

The above data show the extrinsic value of this Innovation Project (value to the people involved, in this particular case, the students). In other words, that all intrinsic values in the project have turned out to be a new, original, and valuable experience for students, as referred to by them, as we shall analyze later on. These intrinsic values have been identified as critical components in the interrelated activity plan offering a real life work experience in a real laboratory which provides service to the aeronautic industry in the resolution of real problems. As a group activity, it has required different types of integrated activities: collective orientation activity, group activity and individual activity, which demands using learning contents of practical and future professional value. In the innovation literature at the university, we have observed results related to very specific teaching problems: teacher innovation and use of ICT (Marcelo, 2002), success conditions in group work in engineer training (Pérez et al., 2013), student difficulties to develop generic competencies (Serrano et al., 2014), etc. However, we have seen little reference to the issue of working with real problems in engineering, although there is some experience in projects for real situations in the master's program of Soares, Sepúlveda, Monteiro, Lima & Dinis-Carvalho (2013). Such is not the case for the bachelor's degree, as presented in the case below, and this is the result we find interesting, specifically in the first courses at the university.

Students' Personal Opinion on the GAA: Qualitative Data

This section analyzes the students' personal comments to the open question at the end of the survey. The quantitative content analysis (Stake, 1998), carried out inductively (Hamilton & Corbett-Whittier, 2012), led us to group individual opinions under three categories. We will exemplify these categories with some of the students' own texts.

1) The first category gathers commentaries on the visit to the laboratory. Here we can observe great interest generated by this GAA, the relations established between theory and practice, between practice and theoretical content learning, and the professional usefulness perceived. Moreover, many of the students would agree to pay these kinds of visits more often, that is, they suggest these activities should be part of the curricula and not just be programmed as an additional activity, since they enable knowledge of future materials, the comprehension of the subject and professional training. Furthermore, nevertheless, they express their enthusiasm and definitely their motivation to visualize concepts, which was a key objective in the project (due to space restrictions, we only offer some examples out of the 23 texts available):

> "We have been able to observe directly everything we have done in theory class. The visit was quite good; we were able to see up close some materials which will most likely be the most used in the future …" (Surv. 3)

> "The visit was an amusing and educational activity ... We saw the theoretical concepts studied in class, which is useful to understand those concepts better and, at

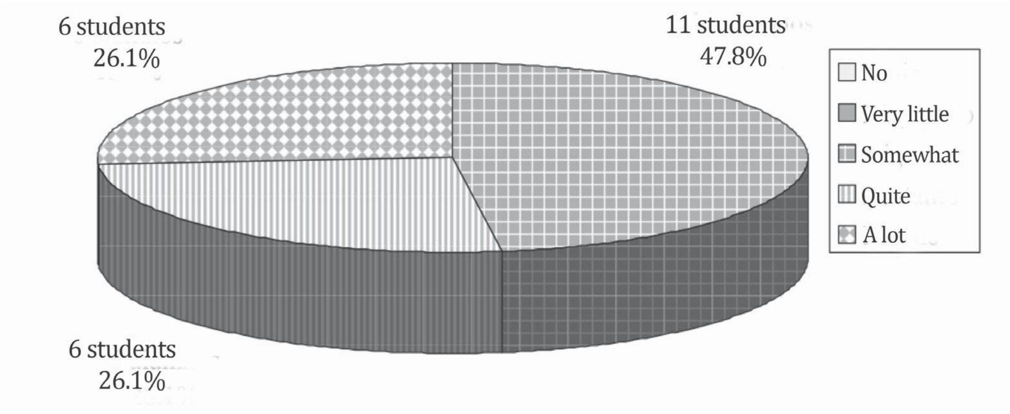

Figure 6. Results of question 3 in the survey: *Do you believe that the visit has helped you strengthen some of the concepts taught in the course?*

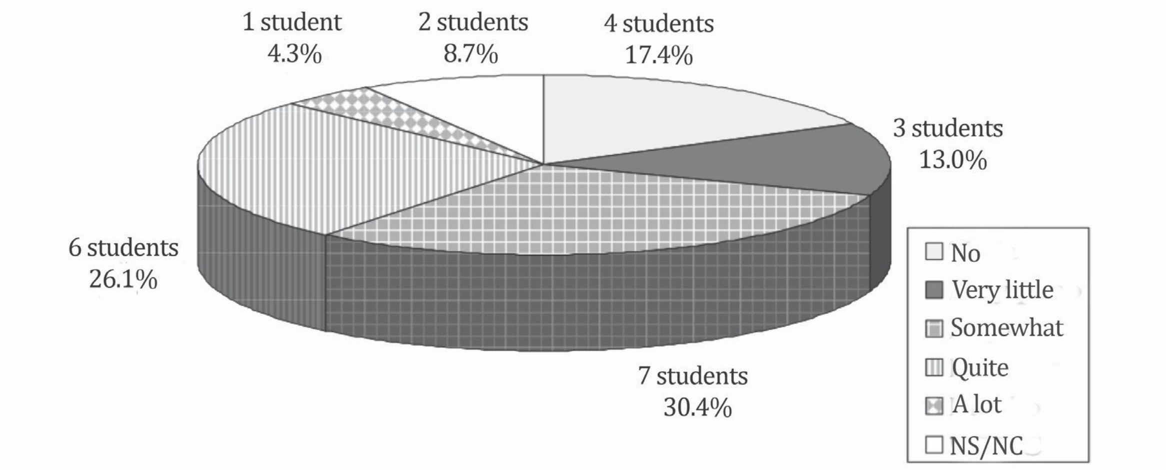

Figure 7. Results of question 4 in the survey*: Do you consider that the WebCT exercises in relation to the visit helped you to study the subject?*

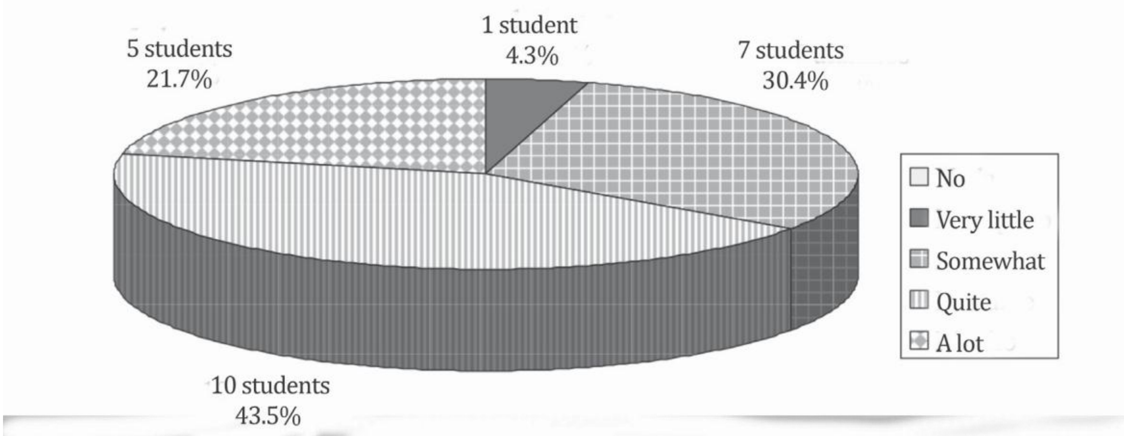

Figure 8. Results of question 5 in the survey: *Do you believe the content related to composite material (not considered in the course) is relevant to your training?*

> the same time, review them. We also saw some curiosities about certain materials, which always attracts attention." (Surv. 9).
> "I feel it's been interesting to see the machines there are in La Cartuja and the tests than can be done with them, since here in the Polytechnic School, we don't have them and the exercises were good, but since I did them at the end, they were not useful to study." (Surv. 12).

2) The second category of comments are those referred to the individual online activity. Many of them deal with the qualifications obtained automatically through the WebCT, and their dissatisfaction and clarification of the problems encountered. On this issue, course teachers realized that many of the failing results were due to the fact that the application only recognized periods and not commas for decimals (many students used commas). The second most common cause for errors was that the application only considered one solution as good, the exact solution, disregarding little variations because of rounding off. For qualification effects, the correction of these errors was done manually by teachers.

> "The visit… interesting. But the exercises in the WebCT had little to do with the visit; besides, the correction was not appropriate because of the decimals in the answers. I have not been graded correctly." (Surv. 5).

> "About the exercises in the WebCT, I think they do not relate much to the visit, the level of difficulty was too high and, in relation to the correction, I do not agree with some of the results." (Surv. 10).

Not all opinions agree on this issue. In fact, opinions like this are fewer. Others value these same exercises positively:

> "With regards to the web exercises, they are useful to put formulas and theorems, as well as procedures, into practice. They are feasible and very useful to deal with concepts we need to understand thoroughly for problems of greater difficulty. In exercise 2, calculating the charge for the first material to fail is confusing. One might think we are dealing with the material numbered 1, when in fact it is about the first material to fail, which is number 4." (Surv. 9).

3) The third category refers to organizational aspects of the GTA and illustrates the time dedicated and its effectiveness, the groups, or difficulties in dealing with ICTs. It also suggests the need to organize these activities with a feedback effect for the teachers involved, generating energy and enthusiasm for them as well:

> "In general, I think it is an important and productive activity, as we learn a lot in very little time." (Surv. 23).

> "The groups were not big, which is appropriate in these activities ... It was an entertaining activity. It allowed us to get familiar with different machines and materials, learn different concepts and see theory concepts live." (Surv. 9).
> "As to the exercises, I haven't found any. I guess they have not been uploaded yet or I'll have to ask where they are … It's a first approach to our work life, at a practical level, which is not possible through teaching in class. We have reinforced some knowledge and gained some more, besides experiencing for a few hours the treatment, work and maintenance that test laboratories of

such characteristics imply … On both educational and instructive grounds, I encourage teachers of this course to repeat the experience in the following years, and even increase the number of visits. I'm taking a good memory of this, and …" (Surv. 7).

Students' personal opinions strengthen the concept of situated learning value: real work scenario, participation in the activity, interaction with teachers and peers, and learning of competencies as the objective.

Global Assessment of the Project: Innovation as Training

Participating teachers have reflected on the data obtained through observation and the correction of individual and group assignments, as well as on the results and students' opinion data. Their assessment refers to:

1) **Accomplishment of the objectives**, since project results are integrated with the competencies the program evaluates: concepts vs. reality, studying new materials and using material strength principles, developing of problem-solving skills, organizing and planning learning tasks, team work, strengthening professional motivation and developing professional ethics. This latter was observed in the responsibility with which students handled machines, equipment and materials; also, the responsibility in their commitment with their teams and the group's success, and the honesty with which students have recognized their interest, learning and difficulties.
2) **Value of activities suggested.** They have been coherent with the active methodology objectives: 1) problem solving, which triggers the activation of cognitive competencies and 2) team work competencies to foster social and ethic competencies.
3) **Three-dimensional assessment of the work carried out by students:** collective (active participation and attendance), team (problem solving) and individual (answering questions online). Results have shown the relation between their participation in the GTA and their performance in the course.
4) **Innovation project implementation** from the personal viewpoint of teachers and students. Both have obtained the satisfaction generated by the participation in the GTA. Both recognize it has been a learning opportunity.

CONCLUSIONS: FACTORS INFLUENCING IN THE EXPERIENCE SUCCESS

The valuation of this Innovation Project is coherent with the perceptions of teachers, experts and students. What have we learned about teacher innovation? We have classified the influencing factors in the success of this experience and they can be applied in other contexts:

1) The suggestion of the activity itself was very attractive to students. Indeed, they requested their participation in the activity, which was added to the mandatory assignments in the course, and almost 60% participated. Moreover, other students in the major who were not registered in the course also took part.
2) The students who carried out the GTA present a high percentage of success in passing the course. In relating their participation in the GAA and qualifications, we find that 90% of the students who passed the course had completed the assignments.

3) As for the value of the GAA itself, it has had significant influence in the teacher/student rapport, and student/student rapport. This is a fundamental success factor of the experience, which has influenced both teachers and students' satisfaction. They are not only analytical and rational, but also sensitive to success and failure (De la Torre & Tejada, 2006). The close teacher/student relationship, established while carrying out the activity, has strengthened confidence, achieving greater participation in theory classes (explanations, whiteboards).
4) The analysis of the students' opinion survey on the GAA show a significant satisfaction level with this innovation.
5) With regards to the development of the project, the joint planning of the two teachers involved in this innovation, as well as the assessment and analysis of the students' results and commentaries have represented good teaching/learning opportunities. Having the collaboration of an expert professor in educational innovation of the School of Educational Sciences has been interesting for the formalization of professional knowledge, according to the research experience in Teacher Training (Fletcher & Mullen, 2012).
6) This is an innovation that shows the possibility of using different resources in the university efficiently, as long as this is done in coordination with the service providers. This is an essential condition for project feasibility.
7) We would also like to emphasize the importance of the institutional framework. We not only had the university support, but the university itself drove the initiative through its invitation to participate in teacher innovation projects, seen as a way to improve teacher quality thanks to the link between innovation and training of teachers who get involved and take responsibility.
8) Finally, we would like to point out the added value of this activity for its transferability. Although this activity was designed for a specific subject, it is easily transferable to others in various bachelor programs, such as Mechanic Engineering, Aerospatial Engineering, Industrial Technologies, Chemical Engineering and Civil Engineering.

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