Academic Effects of a Mixed Teaching Methodology Versus a Teacher-Centered Methodology and Approaches to Learning[1]

Efectos académicos de una enseñanza mixta versus metodología única centrada en el profesor y enfoques de aprendizaje

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Abstract

Recent research in the area of higher education appears to indicate that a mixed teaching methodology that combines direct instruction by the teacher and student-centered activities improves the quality of learning, as indicated by student satisfaction and academic performance. However, the successful implementation of such methodology depends to a great extent on the teacher's understanding of how students approach their learning. In light of this thesis,

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the present study seeks to: (1) identify the engineering students' approaches to learning; (2) determine if a mixed methodology that combines lectures and problem-based learning (PBL) activities improves the quality of students' academic results more than traditional teaching methodology that consists primarily of the teacher's explanations and assignments; and (3) explore the relationships between students' academic results and the approaches to learning and the teaching-learning methods that have been investigated. Utilizing a quasi-experimental design, 160 engineering students were divided into two groups: an experimental group where students completed the course with a mixed teaching methodology, and a control group wherein students attended a course following a more teacher-centered methodology. The analyzed results show that engineering students mainly adopt a deep learning approach. One of the main findings of this study is that a mixed methodology, such as the presented in this work, is more effective because it improves students' satisfaction and academic performance significantly. It also promotes deeper processing than a teacher-centered methodology that is based on lectures and individual practical assignments. In addition, it has been supported that the main approaches to learning that the students in the study used are not consistent. The methods that they use vary significantly depending on the requirements of the instructional context and how students understand it.

Keywords: Higher education, problem based learning, direct guided instruction, approaches to learning, satisfaction

Resumen

Investigaciones recientes en el ámbito universitario parecen demostrar que una metodología mixta de enseñanza directa del profesor combinada con la actividad del estudiante mejora la calidad del aprendizaje, entendido ésta en términos de satisfacción y rendimiento académico. Sin embargo, su implementación exitosa depende en buena medida de un conocimiento básico del profesorado sobre el modo que tienen de afrontar el aprendizaje sus estudiantes. De acuerdo con estas tesis, el presente estudio tiene como objetivos: 1) analizar los enfoques de aprendizaje de estudiantes de ingeniería; 2) comprobar si una metodología mixta, donde se combinan estratégicamente lecciones magistrales y actividades de aprendizaje basadas en problemas (PBL), mejora la calidad de los resultados académicos en comparación con una metodología de enseñanza más tradicional centrada principalmente en las explicaciones y asignación de tareas del profesor; 3) explorar las relaciones entre los enfoques de aprendizaje, las diferentes metodologías de enseñanza-aprendizaje y los resultados alcanzados por los estudiantes. Utilizando un diseño cuasi-experimental, 160 alumnos de grado y máster, de la asignatura "Proyectos" de dos universidades españolas, fueron asignados aleatoriamente a dos grupos: uno, experimental donde los estudiantes cursaron la asignatura según la metodología mixta; y un grupo de control en el que los estudiantes cursaron la asignatura conforme a un diseño centrado en el profesor. Los análisis efectuados indican que los estudiantes de ingeniería adoptan principalmente un enfoque profundo. Asimismo, aquellos estudiantes con enfoque profundo en una situación de aprendizaje mixta, experimentan un mayor nivel de satisfacción con el proceso formativo y obtienen puntuaciones más altas en términos de rendimiento académico, frente al resto de estudiantes. Además, se constata que los enfoques de aprendizaje adoptados por los estudiantes investigados no son estables, variando de forma significativa en función de las exigencias del contexto instructivo y la interpretación que hacen dichos estudiantes del mismo.

Palabras clave: educación superior, aprendizaje basado en problemas, clases magistrales, enfoques de aprendizaje, satisfacción

Introduction

In higher education it is of great interest to have scientific evidence about the effectiveness of different teaching methodologies to ensure students achieve quality learning (Azer, 2009; Baeten et al., 2016; Biggs & Tang, 2011; Gargallo et al., 2018). Furthermore, the European Commission/EACEA/Eurydice (2018), after years of analyzing and publishing successive reports and recognizing significant progress in the learning outcomes of university students, continues to consider that improving the quality of teaching and learning in higher education is linked to research on such processes. For this reason, one of its priorities is to promote research in this area. Regarding teaching methodologies, the predominant assumption in the European Higher Education Area (EHEA) that student-centered teaching methods promote higher quality learning outcomes than teaching-centered methods is being questioned by empirical research in this field (Azer, 2009; Carriger, 2016). These studies invite to adopt mixed teaching methodologies that combine teacher-centered methods with others that are focused on the student (Azer, 2009; Baeten et al., 2013; Carriger, 2016). This hybrid methodology seems to be more effective that any of the component practice when employed separately. In our opinion, the investigation of these mixed methodologies represents a very interesting avenue of research to prove it and, consequently, this work is intended to contribute to this field.

It is also relevant to understand the relevance of the deep approach to the quality of academic results, as shown by some researchers: Biggs (1987, 1988), Biggs & Tang (2011), Chin & Brown, (2000), Marton &

Säljö (1997). Nevertheless, this relationship has been questioned, among others, by Dinsmore & Alexander (2012) and, therefore, the existence or lack of this relationship is a relevant question for research. In the context of Spanish universities, authors such as De la Fuente et al. (2008), Gargallo et al. (2015) and Valle et al. (2000) suggest that students who mainly adopt a deep approach to learning tend to have greater expectations of succeeding, higher levels of satisfaction with the educational setting, and higher levels of academic performance than those students who use a surface approach in the same educational context. Thus, the present work, which is based on the Bigg's (1993) 3P ecological model of learning (Presage-Process-Product), attempts to shed light on the relationships between different teaching methodologies, the approaches to learning that the students adopted and students' learning outcomes. Bigg's (1993) 3P model was chosen because it provides a useful framework for understanding relationships between students' perceptions of their academic environment (*Presage*), learning strategies (*Process*), and learning outcomes (*Product*). This work defines students' learning outcomes in terms of academic performance and student satisfaction. In accordance with Parasuraman et al. (1988, 1993), we understand the level of student satisfaction to be the relationship between expectations and perceived learning. Regarding the academic performance, we approach this concept in the same way as De la Fuente et al. (2008) did. That is, we examine the level of achievement with learning standards that specify what students should know, understand and know-how from a competence perspective.

Students' Approaches to Learning and Quality Learning

Research of approaches to learning has highlighted the influence of students' approaches to learning on their academic performance at the university (Biggs, 1987, 1988, 1993; Biggs & Tang, 2011; Marton & Säljö, 1976, 1997). However, the magnitude of this effect on the quality of the results, as well as the conceptualization of the most important approaches that are adopted during the educational practice, continue to be an important topic of scientific debate and controversy (Dinsmore & Alexander, 2012). Therefore, for the methodological design of our research and interpretation of the results, it is necessary to specify the most important factors that define the most relevant approaches to learning that have been identified in the scientific literature. The concept of approaches to learning, on which this work is based, refers to the processes that each student develops when he/she faces the tasks that the teaching environments impose. Consequently, the students' motivation to learn and the strategies that they adopt are important variables of these processes. These variables reflect their understanding of learning, their personal characteristics and their perception of the teaching context (Biggs, 1988; Biggs et al., 2001; Entwistle, 2009; Marton & Säljö, 1976). It should be noted that this teaching context includes the intentional influence of the teacher due to the teaching methods that he or she uses, among other relevant factors.

Starting with the seminal work of Marton & Säljö (1976), two learning approaches have been identified – surface and deep. Later, a third style that is termed strategic (Entwistle, 1987) or achieving (Biggs, 1988) was described. However, some researches (Zeegers, 2002) suggest the convenience of using the first two approaches, because the strategic (or achieving) approach must be considered to be a component of the deep approach related to the regulation of such aspects as the effort or time required for the learning task.

Regarding the factors that define these approaches, quality learning tends to be related to deep processing (Baeten et al., 2013). This quality learning occurs because students find course contents to be interesting *per se* and have a sense of curiosity, need to understand the subject or material, delve more deeply and learn more. Furthermore, studying and learning generate them a great level of satisfaction by using high-order cognitive processes (Biggs & Tang, 2011). Also, students face their academic tasks as challenges and the effort that is required to learn stimulates them (Biggs, 1988). In short, students' motivation is genuine and intrinsic (Biggs, 1987; Biggs et al., 2001; Biggs & Tang, 2011). This motivation leads students to adopt strategies that will enable them to achieve the goals they consider to be valuable. An example is working hard to broaden their knowledge, ensuring their understanding of meanings and structures, posing questions and reaching their own conclusions (Biggs et al., 2001; Marton & Säljö, 1997; Trigwell & Prosser, 1991). In contrast, the surface approach seems to be associated with lower quality learning results (Biggs & Tang, 2011). This style of learning is observed in those students who seek to complete an assignment with the least effort possible and who exhibit little personal engagement during the learning process. These students are also characterized by a moderately high level of extrinsic motivation toward learning, as they view learning as an imposition. In general, these students demonstrate cognitive activity that could be described as of a low level of complexity. It is based primarily on processes of rote memorization and literally repeating the material that has been studied as a set of unrelated facts (Trigwell & Prosser, 1991).

Even so, other studies in this field (e.g., Chin & Brown, 2000; Struyven et al., 2006) suggest that teachers could motivate students to adopt processes and tasks that enable deep learning. These studies appear to demonstrate that many of the factors that characterize different approaches to learning can be improved by a suitable teaching methodology.

Teaching Methodologies

Research on teaching approaches has identified trends that, in a very simplified way, polarize towards two different positions (Prosser et al., 2005). On the one hand, the teaching methodologies that are based on teacher-designed and teacher-led instructional approaches. On the other, the methodologies where students play an active role in the construction of coherent and organized knowledge by participating in problem solving in relevant learning situations. The proponents of the first position believe that students should receive direct instruction and should not be expected to discover such information by themselves. These studies provide evidence of the superiority of direct guided instruction (Kirschner et al., 2006) and consider that only when the students had sufficient previous knowledge to follow their "own internal guide," student-centered teaching methods should be favored. In the second position, the proponents maintain the hypothesis that people learn better with only moderate or minimal guidance. Consequently, they encourage the student to discover or create essential information by himself or herself.

Although unguided or minimally-guided methods of instruction are very popular, the educational research has not reached a decisive conclusion on their effectiveness in improving the quality of learning. Thus, it is observed a third position that considers the potential effectiveness of the combination of previous approaches. Consequently, we understand that

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a teaching methodology that strategically combines both approaches can foster the benefits of both of them. Indeed, this seems to be supported in a study of students' conceptions of the effectiveness of different learning environments, which reveals clearly the students' preferences for methodologies based on content and expository teaching (Navaridas-Nalda & Jiménez-Trens, 2016). Additionally, Baeten et al. (2013) conclude that the efficiency of teaching methods is increased by combining student-centered methods, such as CBL (case-based learning) or PBL (problem-based learning), with those that are based on teachers' explanations (lecture-style classes). Azer (2009) defends the value of the expository methodology in a context that combines PBL and lecture classes, wherein it makes a key contribution for effectiveness development. In this sense, it appears to be supported that (Biggs & Tang, 2011) adequate explanations by the teacher that stimulate students' active participation facilitates the mental and emotional atmospheres that are necessary to create an environment that is conducive to deep learning.

In regard to learner-centered teaching in higher education, many authors (Dochy et al., 2003; Loyens et al., 2015) highlighted the pedagogical potential of methodologies based on projects and problem-solving to promote higher-order cognitive activity in students. More specifically, in the field of engineering, Yadav et al. (2011) concluded that by using a PBL methodology, learning results can be double those that are obtained by traditional methodologies. Prince & Felder (2006), on the other hand, compared traditional deductive methods to various inductive methods, including PBL. They found that the latter were generally more effective than the former. Although these results are of great interest in defining the problem that is the subject of our study, the work that was undertaken by Dolmans et al. (2016) is equally interesting. The latter concluded that the academic effects of a teaching methodology that is based on inquiry, as is PBL, depend to a large extent on how the methodology is implemented.

The Present Study

In view of the evidence summarized in previous sections, we propose to analyze the effects of a mixed methodology that combines direct instruction and PBL compared to those derived only from direct instruction, relating both teaching methodologies to the learning approaches of students of engineering, its learning outcomes and degree of satisfaction

It is worth mentioning the interest of engineering students in this research. There is a long tradition and abundant literature of educational research on PBL and PBL combined with other methodologies that apply to medical students. To a much lesser extent, there are studies in economics, administration and business, teacher education and engineering. However, to the best of our knowledge, not much is known about the effects of mixed methodologies on deep and surface learning in engineering. Thus, this work attempts to help to fill this dearth of studies that compare the effects of a mixed methodology to those of a traditional, lecture-based instruction in engineering. Also, the purpose of the present study is to contribute to our understanding of student learning in higher education.

Based on the foregoing, our research hypotheses are as follows:

H1. The number of engineering students that primarily adopt a deep learning approach to their education is greater than the number of engineering students that mainly adopt a surface approach.

H2. The strategic use of a mixed teaching methodology – PBL and teacher-regulated activities such as participatory lectures – considering herein engineering students, improves the academic performance of those students who primarily adopt a deep learning approach, as well as their levels of satisfaction with the teaching-learning process, in comparison to the more predominant traditional methodology that is based on an expository approach.

Method

Research Design and Research Context

A quasi-experimental design was established to verify the research hyphoteses of this work. The design focuses on gaining an understanding of the relationships between learning outcomes in engineering, approaches to learning and teaching methodologies. Specifically, two different teaching methodologies –a lecture-based approach and a mixed approach– were applied in project management courses that are taught in the fourth-year of the Mechanical Engineering B.Sc. curriculum and the

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first semester of the Industrial Engineering M.Sc. curriculum. The courses were taught by the same faculty members, three of the present authors. Although these authors currently work at two different universities, they initially worked together at the same university. It is important to emphasize that they communicate regularly with each other and maintain a high level of coordination of their activities. Indeed, the syllabus and resources used during the classes were designed jointly.

Both, the lecture-based approach and the mixed approach consisted of weekly, two-hour lectures. Thus, the content was the same for all students in the same degree program. The content was based on both PRINCE2™ (Projects IN a Controlled Environment) methodology (Office of Government Commerce, 2009) and International Project Management Association (IPMA) competences (IPMA, 2006), but with a different intensity and emphasis for each degree program.

Differences between the teaching methodologies were found in the practical activities (see Table 1). Thus, students within the lecture-based approach were required to complete individual assignments by use of a particular project management technique or a specific tool during the course. The assessment rubrics were distributed to students at the beginning of each task or activity, which were graded upon completion. However, an ill-structured, real-world problem (PBL) was used in the mixed approach. This way, students following this approach were organized in virtual project teams to develop the same project in a competitive manner, with project teams competing with each other. The main goals of this competition were to encourage students to do their best and to enliven the course environment.

TABLE 1. Differences Between the Practical Activities of the Two Course Sections Analyzed

Variable	**Course section**	
	Experimental group	**Control group**
Type of as-signment	Ill-structured, real-world problem to be developed in project teams. It involves individual and teamwork.	Well-defined tasks or exercises concerning real-world problems to be developed individually
M.Sc. students' specific activities	– Project's business case – Project's scope definition – Project planning and scheduling – Project's risks management – Project's changes management – Project monitoring and control	– Business case exercise – Scope definition exercise – Project planning and scheduling exercise – Risks identification exercise – Change control strategy exercise – Work package definition exercise
B.Sc. students' specific activities	– Project's feasibility analysis – Project's formal documentation, including design calculations, drawings, formal budget, health and safety issues, and work scheduling – Scheduling work package time and resources – Monitoring work package performance	– Feasibility analysis exercise – Drawings exercise – Formal budget exercise – Health and safety issues identification and proposal of countermeasures – Time and resources scheduling exercise – Monitoring performance exercise
ICT tools	Online project management tool, 360-degree assessment web, Moodle, specific budget software	Standalone project management tool, Moodle, specific budget software
Assessed competences	Technical and behavioral competences assessment on a regular basis.	Technical competences assessed at the end of each assignment.
	Assessment involves several pieces of evidence that are relevant to each competence. They are distributed to students as grading rubrics.	

More specifically, the PBL methodology was designed for students' acquisition of the competences related to project management (González-Marcos et al., 2016a). Therefore, with the goal of fostering learning in a real pedagogical context, students from different degree programs and universities were enrolled in a project development process. They worked as a team in the realization of real-world engineering projects. A set of resources that describe the assessment procedures and instruments, the quality criteria for products and processes, and specific procedure manuals that could be useful in completing the project were provided at the beginning of the semester. Then, a project mandate – created by a client (the teachers) – with an outline of the business case and the need of the project was presented to each team. After the project was launched, each team was responsible for providing the client with the required project's products within the agreed deadline and cost. The management and organization of the projects was carried out according to the PRINCE2™ methodology. Thus, as in professional projects, activities, such as scope definition, planning and risk management, etc. were carried out during project development. Also, students assumed different roles with different functions and responsibilities. These ranged from those with greater management responsibilities (executives, EX) to project engineer (team members, TM), whose role in management was rather limited. Other roles were project manager (PM) and team manager (TMg).

FIGURE 1. Hierarchy and Roles of Project Participants

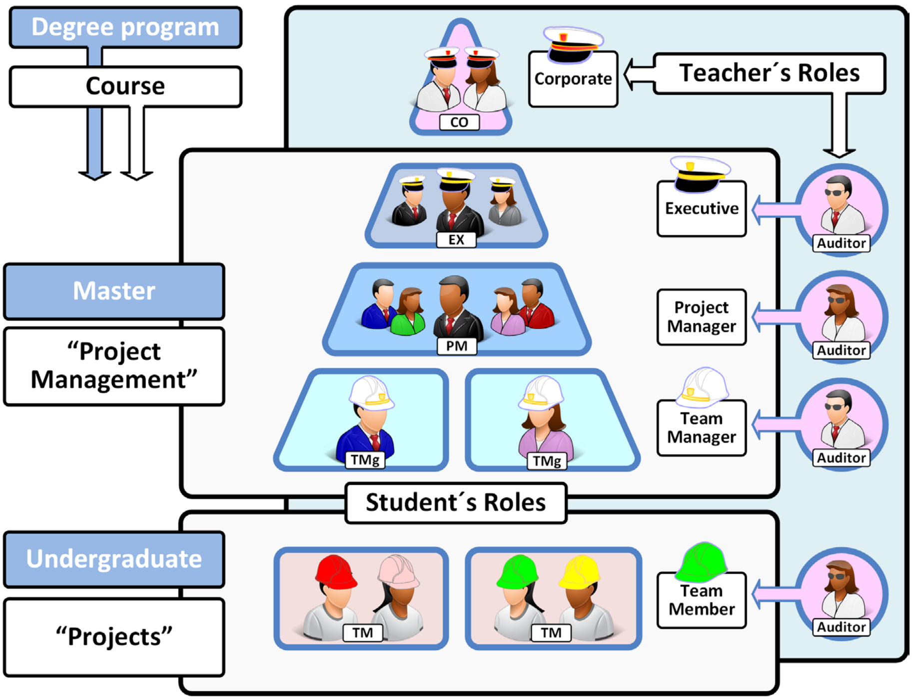

Figure 1 illustrates the different roles that students undertook, all of which are specific roles that are defined by PRINCE2™. The faculty members also adopted two different roles – corporate (CO) and auditor. The corporate owns the environment and is responsible for commissioning the project and following up to ensure the benefits of the project. The auditor acts as facilitator. He or she checks the progress of each team periodically, answers questions, asks questions, or advises of any corrective actions that are necessary.

In order to continually assess each student's acquisition of the competences, the participants (teachers, peers, and learners) were required to answer questions regarding the quality of the products created, the execution of the PRINCE2™ processes and behavioral competences (González-Marcos et al., 2016b). Therefore, each participant evaluated all other participants. The results of these evaluations were submitted periodically to students (González-Marcos et al., 2016a).

Participants

The participants in this study were 160 engineering students of two separate universities that are located in different regions of Spain. These engineering students were either fourth-year undergraduates (B.Sc.) or first-year master's degree (M.Sc.) students who were enrolled in project management courses scheduled for the fall semester. The analysis includes students from the last two academic years.

Students were randomly divided into two course sections. This division was subject to the constraints of geographical location, degree program, and learning approach. Thus, 82 students – the experimental group – used the proposed mixed approach and 78 students – the control group – used a more traditional, lecture-based instruction (Table 2).

TABLE 2. Number of Students by Degree Program and Course Section

Degree program	Experimental group	Control group	TOTAL
B.Sc.	45	45	90
M.Sc.	37	33	70
TOTAL	82	78	160

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Instruments

Approaches to Learning

The approaches to learning that were mentioned in this study were assessed by using the Spanish version (R-CPE-2F) (Hernández-Pina & Monroy, 2012) of the revised two-factor study process questionnaire (R-SPQ-2F) (Biggs et al., 2001). The developers of this questionnaire reported that it was empirically validated at an exploratory and descriptive level (Hernández Pina et al., 2004). This instrument was selected because it is consistent with our approach, which is based on the 3P ecological model of learning. In this study, the questionnaire included 20 items corresponding to the learning approach dimensions, deep and surface. Students gave responses on a Likert-type scale, from 1 (never o rarely true for me) to 5 (always or almost always true for me). In order to determine the reliability of the 20-item instrument, Cronbach's alpha was utilized. In the current sample, the internal consistency coefficients (Cronbach's alphas) were.83 for the deep approach and.84 for the surface approach, which exceed the.7 threshold recommended by Nunnally (1978).

Student Satisfaction Questionnaire

Student satisfaction was measured by means of an *ad hoc* questionnaire based on SERVQUAL (Parasuranam et al., 1988, 1993). The adapted SERVQUAL, which was tested for content validity (González-Marcos et al., 2016a), consisted of 17 questions (items) about the following six dimensions: Access, Tangibles, Reliability, Competence, Responsiveness and Relevance. The full set of statements used in the final questionnaire is included in Appendix Figure A1 at the end of this paper.

The students were asked to indicate their agreement or disagreement with each statement on a five point Likert-type scale that ranged from 1 to 5, where 1 indicated strong disagreement and five indicated strong agreement. The current-sample Cronbach's alpha values were.70 for Access,.75 for Tangibles,.91 for Reliability,.77 for Competence,.89 for Responsiveness and.83 for Relevance. The Cronbach's alpha of the entire scale was.94. The coefficient value for Access dimension was the lowest, but still within the acceptable range for measurements that are developed and used for research purposes (Nunnally, 1978).

Pre-Test/Post-Test Evaluation

A pre-test/post-test questionnaire was adopted for each degree program to determine how well the proposed methodology had improved the acquisition of course concepts. The pre-test was administered at the beginning of the course and the post-test was conducted at the end of the course.The results of these tests were not included in the students' final marks to avoid any student preparation and study time. The aim was to obtain adequate and unbiased information.

These instruments, which were specially designed, included the main concepts that were reviewed in each degree program. Thus, 43 questions for undergraduate students and 53 questions for the masters' students were used to obtain indirect information of the extent to which the learning experience had changed the students' minds. A check of the internal consistency of this instrument yielded a Cronbach's alpha of.79 on both cases, which exceeds the minimum value of.7 that is required to prove reliability (Nunnally, 1978).

Learning Outcomes

A student's final mark in the course was a weighted average of the marks that he or she received in the final exam (40%) and for the course tasks and activities (60%). The final exam was administered to evaluate students' knowledge acquisition and consisted of 60 multiple choice questions, which were selected randomly from each course test bank. It is worth mentioning that there were only two test banks, one per degree program. The same instrument was used to evaluate the knowledge that students had acquired from the same degree program at each of the two universities.

Assessment of the course tasks and activities of the experimental group was based on both group and individual performance. That is, instructors assessed the project team's final products quality by means of a rubric that was distributed to students at the beginning of the course

(20%), and the student's individual contribution to the team by continuous assessment of both technical (20%) and behavioral (20%) competences. The assessment of these competences is described in González-Marcos et al. (2016b). In this case, all of the students and all projects' products were graded with the same assessment forms and rubrics by the three faculty members who were teaching the courses. Thus, the final grade was an average of these marks. This reduced instructor and university variabilities.

However, students who participated in a more teacher-centered course design, i.e., the control group, were asked to complete six individual assignments and to apply a particular project management technique or to use a specific tool during the course. Each task and activity was also evaluated by means of a rubric. These rubrics were also the same for all students in the same degree program.

The main differences in the rubrics used for the assessment of the participants in both groups are as follows. First, students in the experimental group were assessed by the three main actors in the learning activities (teacher, peer and learner), whereas students in the control group were assessed by teachers. Second, competences such as leadership, teamwork and negotiation were not assessed for students in the control group since their activities were developed individually.

Procedure

Students who participated in the study completed online the R-CPE-2F and the pre-test questionnaires during the first week of the course before commencing the tasks and activities. After the information about students' approaches to learning and their initial knowledge of project management had been obtained, the students were separated randomly into two groups, according to their geographical location, degree program, and learning approach. One course section – the experimental group – used the proposed mixed methodology, which is based on lectures and PBL. The other section – the control group – used a more traditional course design that was based on lectures and individual assignments.

Lectures were presented to the entire class. That is, there were no differences between what was presented to students in the experimental group and those in the control group in the same degree program and

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university. Students in the experimental group were organized into virtual project teams to develop the same project. Students from the control group were not organized into project teams, but were asked to complete individual assignments.

Finally, students were asked to complete the online R-CPE-2F questionnaire again, as well as the online satisfaction and post-test questionnaires on completion of the course, but prior to the final exam. A total of 160 students completed the initial and final R-CPE-2F, the pre- and post-test questionnaires and the satisfaction questionnaire.

Data Analysis

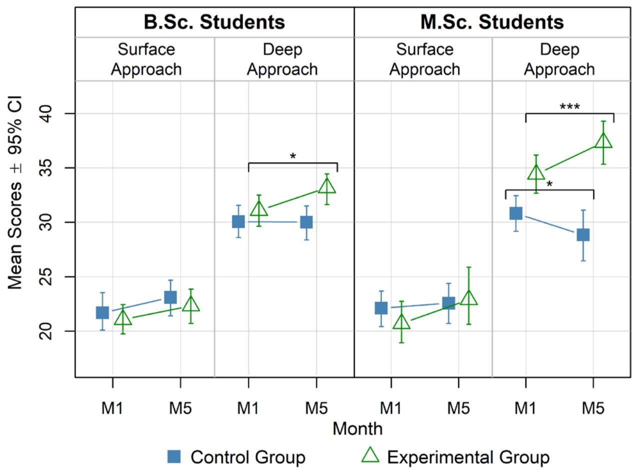
First, students' responses were analyzed using descriptive statistics. Next, to ascertain whether the perceptions and results of the experimental group and control group differed significantly, the Mann–Whitney U-test was employed because the necessary conditions for the t-test could not be assured. The level of significance (alpha) was determined to be.05. The effect size was calculated by means of Cliff's Delta instead of Cohen's d, because the former is more robust for non-normal distributions. In this case, the magnitude was determined using the thresholds that are provided in Romano et al. (2006). This gave $|d| <.147$ "negligible effect," $|d| <.33$ "small effect," $|d| <.474$ "medium effect", otherwise "large effect." Finally, a Wilcoxon signed rank test was undertaken to test for significant difference between two related samples.

Results

Approaches to Learning

Figure 2 shows the evolution of the students' scores in each learning approach dimension that were determined at the beginning (month 1 or pre-process) and at the end (month 5 or post-process) of the course (repeated design). It may be noted that the maximum possible for each dimension is 50. Thus, an examination of the distribution of each learning approach indicated that the deep approach score was greater than that for the surface approach in engineering students, regardless of the degree program and the instructional method. Indeed, at the beginning of the course most students (90%) primarily adopted the deep approach to learning. This supports the hypothesis that engineering students mainly adopt a deep learning approach for their education. Although our analyses included all of the participants, the small number of students who mainly adopted a surface approach (10%) indicates the caution should be exercised when interpreting results related to this group.

FIGURE 2. Evolution of Learning Approaches Scores by Degree Program and Instructional Method



* p <.05. *** p <.001. Significant difference between pre- (M1) and post-process (M5) measure

Another interesting result is the evolution that was observed in the students' scores for each learning approach dimension:

- All of the students (M.Sc. and B.Sc.) in the experimental group increase their scores in both learning approaches dimensions (deep and surface). However, a statistically significant differences between pre- and post-process measurements were identified only for the deep approach. Furthermore, as Figure 3 illustrates, the proposed methodology motivates students to primarily adopt a deep approach to learning.

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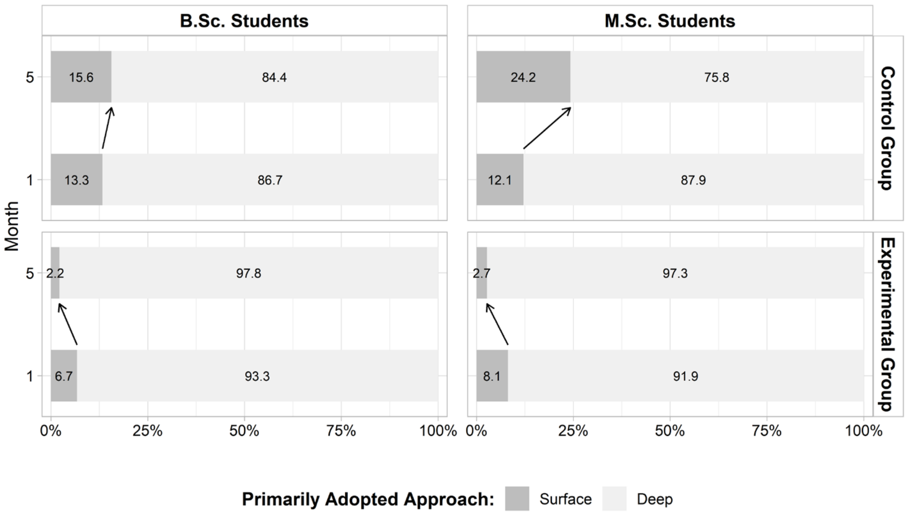
- Overall, students from the control group either increased their mean scores on the surface approach or decreased them on the deep approach. Statistically significant differences were only found between pre- and post-process measurements on the deep approach for M.Sc. students. However, more importantly, students from both degree programs changed their primarily adopted learning approach from deep to surface after the course (Figure 3).

FIGURE 3. Evolution of the Proportions of Surface and Deep Learners by Degree Program and Instructional Method



Student Satisfaction

Descriptive statistics for each investigated dimension appear in Figure 4. They summarize the student perceptions that were obtained by the satisfaction survey. These results indicated that the highest level of satisfaction, with an overall mean value and standard deviation of 4.37±.77, was reported by those students in the experimental group who mainly adopted a deep approach. Indeed, every dimension obtained more than four of the five points possible, whereas the mean scores of students

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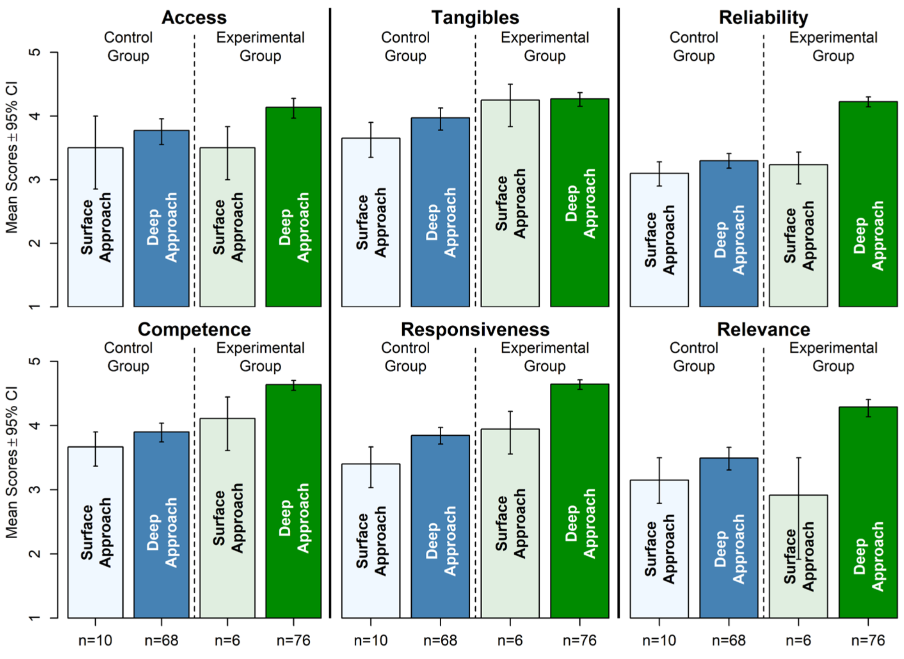
who mainly adopted a deep approach in the control group was less than four. Thus, for engineering students who initially adopted the deep approach, the proposed mixed methodology exhibited a greater overall level of satisfaction during the learning process. On the other hand, the lowest satisfaction scores were obtained from the students who primarily employed a surface approach in either of the two methodologies that were used in this work. Nonetheless, these results cannot be considered to be conclusive, because the number of students who primarily employed a surface approach is small. Although scores from both degree programs are merged in Figure 4, it must be noted that very similar results were found when the analysis was done by degree program.

FIGURE 4. Differences in the Investigated Dimensions of Student's Satisfaction



Further analysis of the students' responses was conducted to determine if students' satisfaction differed in their mean ratings according to learning approach and course section. Once more, similar results were

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found when the analysis was conducted by degree program. Thus, the B.Sc. and M.Sc. students' scores are merged in Figure 5 for purposes of clarity.

Again, students using a deep approach in the experimental group achieved the highest levels of satisfaction. The surface approach, on the other hand, is associated with lower levels of satisfaction regardless of the teaching methodology employed. Despite these results, there were six valuable components - with mean scores greater than four - for all the students in the experimental group. They were related to instructors' knowledge and experience (D.10 and D.11), instructors' support (E.13 and E.15) and the availability and performance of physical and technological resources (B.3 and B.4).

In order to determine if there are any significant differences between the levels of satisfaction of each group of students, a Mann-Whitney U test was conducted. Thus, an analysis of the deep-approach students (Figure 5.b) revealed that there are significant differences in the majority of the items surveyed. The exceptions are three items that are related to the ability of students to organize and coordinate the course with their work or personal responsibilities (A.1 and A.2), and with the availability and performance of technological resources (B.4). In addition, the calculated effect size (Figure 5, bottom) indicates a large effect on five items (C.7, C.8, D.12, E.13, and F.17), a medium effect on seven items (C.5, C.6, C.9, D.11, E.14, E.15, and F.16), and a small effect on two other items (B.3 and D.10). These results support the hypothesis that students who use a deep learning approach feel more satisfied with a mixed teaching methodology that combines lectures and PBL, than with a methodology that is based on the teacher transmitting information and individual exercises.

On the other hand, no significant differences in the satisfaction levels of surface-learning students were identified (Figure 5.a). Nevertheless, as noted above, the group of surface-learning students was small, and, so, a larger sample would be necessary to draw more definitive conclusions.

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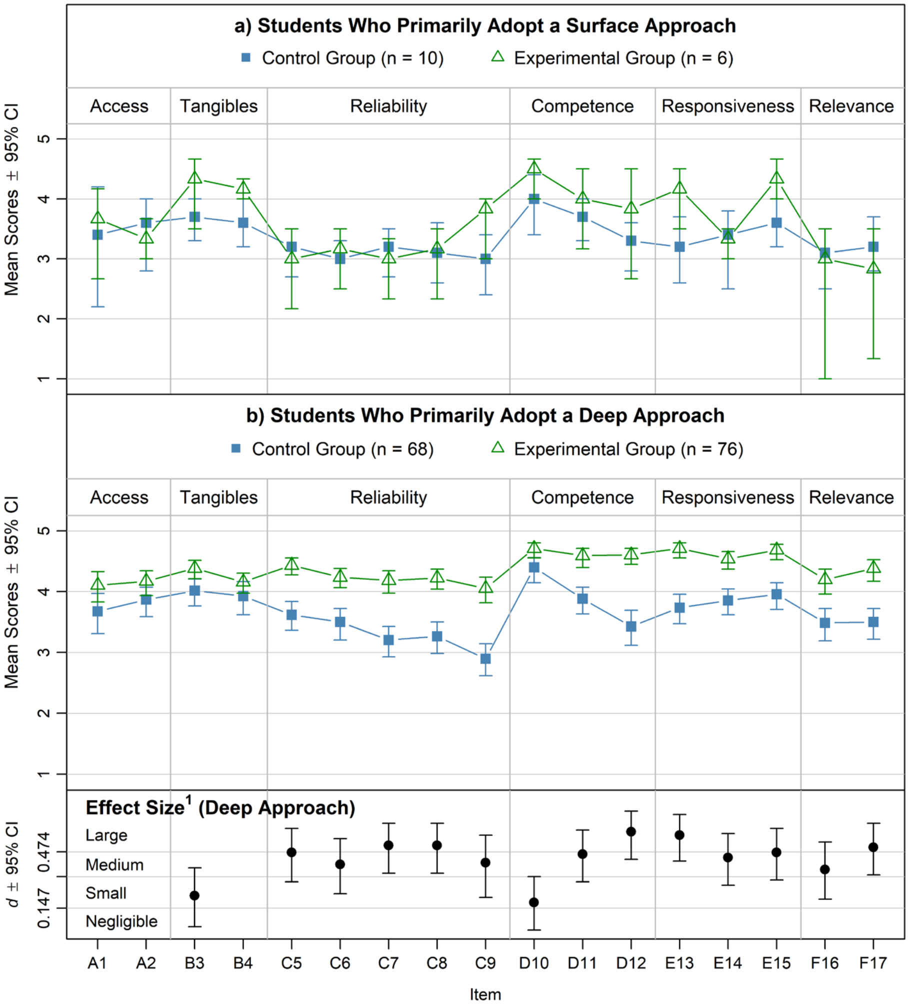
FIGURE 5. Differences between the Students' Satisfaction Scores

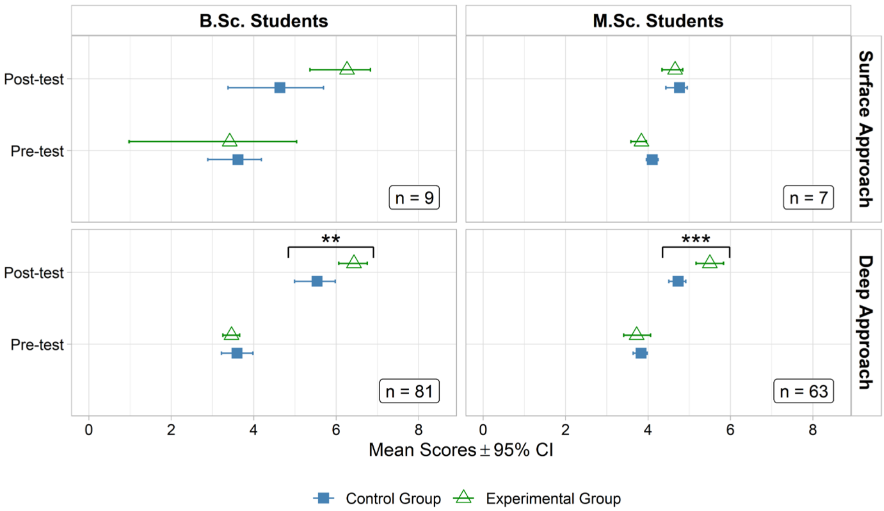


[1] Effect size is meaningful only for cases where a significant difference (p <.05) is found.

Learning Outcomes

First, the students' previous knowledge of project management (pre-test) and their final understanding of course concepts (post-test) were analyzed. Figure 6 summarizes the results of both the pre-test and post-test according to the primarily adopted learning approach of students at the beginning of the course, their degree program, and the teaching methodology that was employed in their classroom.

FIGURE 6. Differences between the Means of Pre-Test and Post-Test Results



** p <.01. *** p <.001

The results of the pre-test show that the students' initial knowledge of project management was very similar in both methodologies that were used in this work (no statistically significant differences were found). For the learning outcome, the post-test results showed an increase in the average number of correct answers for all the students. However, as it is illustrated in Figure 6, students who mainly adopted a deep approach at the beginning of the course had higher scores than their peers who mainly adopted a surface approach. The Mann-Whitney U tests showed a statistically significant difference between the two groups for students that primarily adopted a deep approach in both degree programs: B.Sc. (Z = 2.658, p =.007) and M.Sc. (Z = 3.297, p <.001). The calculated effect size indicates a medium effect on B.Sc. students and a large effect on M.Sc. students.

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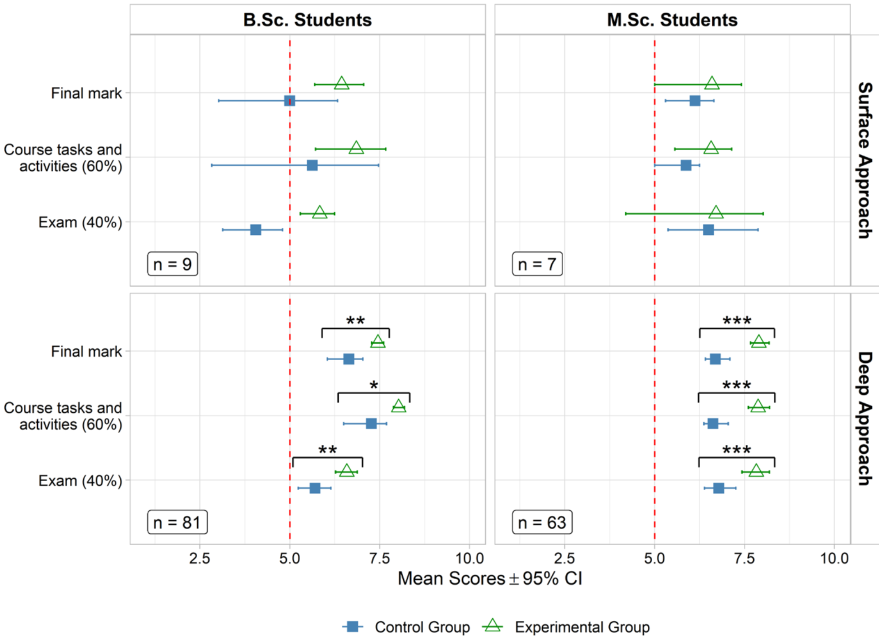
Turning to academic performance, Figure 7 shows students' results according to their mainly adopted learning strategy, their degree program, and the teaching methodology that was employed in their classroom. In order to conduct a more in-depth analysis, the final marks are included, as well as the exam marks (40% of the final grade) and those of the practical tasks (60% of the final grade).

FIGURE 7. Differences between the Means of the Students' Marks



* p <.5. ** p <.01. *** p <.001

Overall, the students who mainly adopted a deep learning approach and attended the course using the mixed methodology obtained the best results (the experimental group). Significant differences can be observed in the final marks, the final exam results, and the practical activities scores of students who primarily used a deep learning approach according to the teaching methodology. As with the pre-/post-test analysis, the calculated effect size indicates a medium effect on B.Sc. students and a large effect on M.Sc. students.

In contrast, the students who primarily adopted a surface approach in the control group obtained the worst results in both degree programs. Although, this is in line with the previous pre-/post-test evaluation results, we must consider them with caution due to the small number of students who mainly adopted a surface approach.

Conclusions

This study investigates the learning approaches that engineering students employ most frequently, as well as the effects of the teaching methodology on the academic results of students who mainly utilize different approaches to learning.

In support of our first hypothesis, our analysis revealed that the deep learning approach was most prevalent among engineering students. It is well recognized that teaching and learning environments, which are characterized by their teaching and evaluation practices, are strong factors in stimulating and influencing students to use mainly one learning approach or another (Biggs & Tang, 2011, Marton & Säljö, 1976). In fact, as Baeten et al. (2016) demonstrate, students primarily adopt a deep approach in order to meet the demands of the student-centered learning environment (such as PBL).

The results of this study also support our second hypothesis as higher levels of satisfaction and better performance were observed for the deep-learning students in the class that employed a methodology that combined certain features of teacher-centered methods (participatory lectures) and learner-centered activities (PBL). These results concur with those of other authors (Ellis et al., 2008; Goodyear et al., 2003) who also have observed a weak positive correlation between levels of student satisfaction and the deep approach, as well as a weak negative correlation between satisfaction and the surface approach. The differences that are found may be due to individual student preferences, as those who adopt a deep approach tend to prefer a teaching style that promotes knowledge construction and cooperative learning; whereas those students who use a surface approach prefer a more guided teaching style (Baeten et al., 2016).

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It is worth mentioning that the results of this empirical study show the higher effectiveness of the proposed, mixed methodology on knowledge acquisition than that of a lecture-based instruction. This is in line with the results of the study carried out by Carriger (2016).

The present study observed that some students moved away from deep learning approaches to more surface approaches in the teacher-centered classroom. That is, students tend to opt for surface strategies if they perceive that their teachers are adopting more teacher-focused approaches (Prosser & Trigwell, 2014). Also observed was how most of the students who initially used more a surface approach changed to the main use of the deep approach in the mixed methodology. Furthermore, none of the students moved away from a deep approach to a surface approach in this methodology. Therefore, this study has verified that students' approaches to learning are dynamic in nature and can be adapted according to the specific teaching strategies in use (Struyven et al., 2006).

Finally, it should be noted that the highest levels of satisfaction in the experimental groups correlated with the following, in this order: (1) the instructor's degree of subject-area knowledge (item D.10), (2) help and support received (item E.13), and (3) the instructor's interest in students' problems and difficulties (item E.15). This finding agrees with other past studies that conclude that students prefer an adequate level of support in learner-centered methodologies (Baeten et al., 2016; Drew, 2001) or, in other words, a combination of characteristics from teacher-centered methods (teacher direction that can offer structure, guidance and support) and learner-centered methods (cooperative learning and knowledge construction). This underscores the usefulness of the proposed mixed methodology.

As with most educational research, this study has certain limitations to address and improve in future research. Firstly, as noted above, the group of surface-learning students was small. Thus, a larger sample would be necessary to draw more valid conclusions. Secondly, the results of this study are limited to two subjects at different universities. Thus, future research should incorporate additional subject areas and/or other universities. This would enable the evaluation of the degree of influence of a specific subject on the results. It also would facilitate examination of how differences in context and instructor styles of the different universities influence the results. Addressing these limitations would enhance the value of the present study.

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Appendix A

FIGURE A1. Questions Used to Measure Students' Satisfaction

Dimension	Label	Item
Access Teachers pay attention to individual student needs and make it easier for their students to follow the teaching and learning process	A.1	I was able to coordinate attendance at this course with my work responsibilities.
	A.2	The course information provided an overview that allowed me to organize my personal agenda properly.
Tangibles Availability and performance of physical facilities and technological resources	B.3	The physical environment of the classroom aids learning.
	B.4	The technological resources were operating throughout the learning process.
Reliability Ability and organization of the educational program to meet the learning objectives	C.5	What I learned from this course is aligned with the course learning objectives.
	C.6	The learning objectives relate consistently to the course contents.
	C.7	The learning strategy has increased my subject knowledge.
	C.8	The learning strategy has improved my skills in the subject.
	C.9	The theory and practice have been adequately balanced.
Competence Knowledge, experience and skills required of teachers to ensure academic performance	D.10	The instructor is knowledgeable in his/her field.
	D.11	The instructor's professional experience fosters a better understanding of the subject.
	D.12	The instructor provides good materials for properly follow up of the teaching sessions.
Responsiveness Willingness and flexibility of teachers to face the problems and difficulties raised by students	E.13	The instructor responds quickly and efficiently to students' questions.
	E.14	The instructor properly coordinates students' interventions.
	E.15	The staff is interested in students' problems and difficulties.
Relevance Appropriateness of the duration and time distribution of the course to facilitate student learning development in present or future performance	F.16	The duration of the course is sufficient to achieve the intended objectives.
	F.17	I can improve my professional competences because of what I learned.

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