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Academic Performance in Blended-Learning and Face-to-Face University Teaching

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Abstract

The benefits promoted by the use of the blended-learning model in higher education have been well studied from a general point of view, but no conclusive results have been achieved so far. However, within the field of engineering, these researches are quite scarce and become even rarer in the case of researches trying to demonstrate whether the benefits of blended learning could be compared to those achieved by classroom education. Learning platforms allow us to incorporate rich learning resources, interactive tools that foster collaborative learning, student to student, student to professor and student-professor-student interactions. Learning platforms also give us the opportunity of incorporating tasks that allow students to check the progress of their own learning processes. This paper presents the results of a research carried out at the School of Technical Architecture of the University of Seville with students enrolled in the Materials Science course. The aim of this investigation was to compare students' results when trained by means of traditional teaching and blended learning. In order to achieve our goal we followed a quasi-experimental, descriptive and correlational design applied to two non-equivalent groups. The results indicated that in the blended-learning model, the students had more academic success as compared to traditional teaching.

Keywords: academic performance, blended learning, materials science, technical architectural, university teaching

1. Introduction

The need for European universities to adapt their degree courses to the requirements of the Bologna process as part of the construction of the Higher European Education Area (EHEA) means that both the institutions –as the bodies ultimately responsible for the process– and the teachers –as the instruments required to enact it– must make major changes, not only with regards to how to conceive the actual teaching and learning programs, but in the methods deployed to comply with the new requirements. It is also worth highlighting the shift from a teacher-based style of learning to another more student-based approach, in which the students themselves become active participants in their own learning process, and are driven to acquire new responsibilities. It is in this regard that it becomes especially important to accept a constructivist understanding of language. From this perspective, students are understood to be active agents that interact with the learning context and are committed with the learning process. Thus, they reformulate new knowledge from knowledge they already had, in an intentional and reflexive manner. In this scenario, teachers play a peripheral role, helping and supporting students as they build and rebuild their own knowledge.

New teaching strategies will be required to allow for the continuous improvement of the teaching-learning process, and to guarantee that the students acquire the necessary knowledge and skills. However it should be noted that the implementation of the EHEA in Spanish universities is running into considerable problems as a result of the high teacher/student ratio, which hinders the personalised student-based teaching approach which responds to a diversity of interests and increases student-teacher interaction.

This research was conducted within the subject of Technical Architecture, part of the Architecture and Engineering degree. It is perceived by students as being extremely difficult, a notion that can lead to a high dropout rate in certain subjects. Students are required to complete 240 credits (1 credit=10 classroom teaching hours), and the duration of the degree is three academic years, plus a dissertation at the end of the degree. The dropout and failure rates for the different subjects in the degree are particularly high. Reducing the dropout rate and increasing academic performance must thus be the key elements underlying all the decisions that are taken. It is therefore necessary to incorporate flexible teaching processes that can be adapted to the students and provide mechanisms for the proper follow-up and assessment of learning.

The question is whether student performance could be improved by the incorporation of Information and Communication Technologies (ICT) in the university classrooms, given that the use of ICT resources appears to enhance educational possibilities (Sussman & Dutter, 2010). Today's students were born surrounded by technology, and are aware on a daily basis of how these media serve to enhance and to enable them to do an ever greater array of things in a more user-friendly and effective way. This raises multiple issues for which there are no easy answers.

2. Background

Numerous authors coincide in believing that blended learning, or hybrid learning, bring together the best from both face-to-face and distance learning methods (Dearnley, McClelland, & Irving, 2013; Graham, 2013; Güzer & Caner, 2014; Halverson et al., 2014; Kwak, Menezes, & Sherwood, 2014; Porter, Graham, Bodily, & Sandberg, 2016; Spanjers et al., 2015).

The problem encountered when deciding on whether to include blended learning in Architecture and Engineering is the lack of empirical studies in the area, since, as indicated by Hölb and Welzer (2010) the research into this area is still in its early stages. In Spain, teachers of technical courses tend to focus their research on advanced studies in the subject they teach, and only recently has there been an interest in learning and diagnosing the validity of current teaching methods and their possible alternatives. The conclusions presented in the articles published by Spanish teachers in this field can be synthesised as follows: students give a positive assessment of their use (Jara, Candelas, Puente, & Torres, 2011; Méndez & González, 2010); increased motivation (Méndez & González, 2010; Vázquez-Martínez & Alducin-Ochoa, 2014); a decrease in the dropout rate (Alducin-Ochoa & Vázquez-Martínez, 2014); and optimisation of the students' work time (Domingo-Calabuig & Sentieri-Omarrementeria, 2011). There are no unanimous conclusions to be drawn from the students' results, and the findings indicate that they are comparable to those obtained with classroom-based teaching (Mora, Sancho-Bru, Iserte & Sánchez, 2012); or that they improve in comparison with the results of face-to-face teaching (Cortizo, Rodríguez, Vijande, Sierra, & Noriega, 2010; Domingo-Calabuig & Sentieri-Omarrementeria, 2011; Jara et al., 2011; Méndez & González, 2010).

Advantages: Blended learning allows physical and temporal delocalisation, although the focus is set in the classroom, the fact of having these resources available increases flexibility in academic performance (Llamas-Nistal, Fernández-Iglesias, González-Tato & Mikic-Fonte, 2013; McKenzie, Perini, Rohlf, Toukhsati, Conduit & Sanson, 2013; Spanjers et al., 2015); the possibility of creating new spaces and scenarios for communication and interaction (Bower, Dalgarno, Kennedy, Lee & Kennedy, 2015; Cunningham, 2014; Yigit, Koyun, Yuksel, & Candaya, 2014); promoting an autonomous learning environment (Adileh, 2012; Dabbagh & Kitsantas, 2012; Georgsen & Lovstad, 2014; Yang, 2012); offering greater knowledge of the students' work (Nizkodubov & Evseeva, 2015; Zacharis, 2015); improving students' processes of reflection and creativity (Buran & Evseeva, 2015; Lee, Choi & Kim, 2013); increasing the student's motivation (Güzer & Caner, 2014; Mora et al., 2012); helping to decrease the rate of school dropouts (Georgsen & Lovstad, 2014; McKenzie et al., 2013).

Some difficulties that present themselves during the implementation of blended learning methods will now be presented.

Drawbacks: A few authors consider the greater time investment a negative element (Buran & Evseeva, 2015; Mahle, 2011; Mora et al., 2012). Others suggest that there is deficiency in the training of the teachers/professors (Szeto, 2014) and the students (Dearnley et al., 2013; Hachey, Wladis, & Conway, 2014) to deal with virtual teaching and incorporate it as an everyday activity. In this sense, it should be noted that both professors and students will have to invest time in technological training to acquire the necessary abilities.

Likewise, the lack of leadership for their implementation (Latchem, 2009), as well as the fact that a great number of professors and students believe that the best teaching method is the one that is eminently face-to-face (Hölb & Welzer, 2010), can be considered to be obstacles for the incorporation of virtual teaching. Some authors include the lack of support and recognition by the institutions of the efforts by the professors that become involved in this type of teaching as obstacles as well (Stewart, Harlow, & DeBacco, 2011; Porter et al., 2016). Also, it should also be noted that, at least in Spanish universities, the teaching innovation activities are not recognized as curricular merits.

As for the new activities that are given to professors in this type of teaching style, among others, the careful programming that is necessary in order to integrate the classroom and the internet activities should be noted (Güzer & Caner, 2014); as well as the support, guidance and drive of the student's interaction and collaborative work (Augustsson & Jaldemark, 2014), for all of this to work, the professor's presence in the different communication channels (forums, chats, class diaries, email) should be guaranteed, as we should not forget that the degree of the student's interaction is subject to that of the professor's (Oliveira, Tinboca, & Pereira, 2011; Totter & Raichman, 2009; Wu, Tennyson, & Hsia, 2010); to that end Cunningham (2014), recommends that the professors establish a maximum response time. Also, if the platform allows for the monitoring of the students, periodic reports should be written to understand what the situation of each student is as far as performance level, if the student is reaching the planned objectives, if the teaching strategies are adequate, among other aspects, in order to offer the oportune feedback to the students, thereby avoiding desertion.

As for the students, although the need for technological training has been mentioned, it is also true that they usually have great abilities in the use of digital communication media (WhatsApp, Facebook, Twitter, Tuenti, among others), but only for a recreational purposes. Now they will have to learn to communicate in order to learn, create knowledge, establish a positive interdependence and share objectives with the rest of the students. This entails a more active performance, to stop being a mere receptor, transforming themselves into a constructor of knowledge, learn to choose what resource is more useful, plan the learning process, evaluate the validity of their decisions, and take, if needed, the necessary corrective actions. The use of an educational platform requires that the student learn how to self-regulate their learning. Although it is true that the resources available in educational platforms are vastly superior to what can be offered in a conventional face-to-face classroom, there was a initial resistance for its use by the students, as it was easier to just memorize the class contents. However, when this resistance was overcome, a great number of students became involved in an efficient manner, and correctly and effectively followed the class.

In addition to these advantages and drawbacks, each university has a series of particularities to be taken into account when designing educational programs in order to ensure that they meet the needs of the labour market and the students' expectations. Blended learning should provide a valuable learning experience that allows students to improve, and its incorporation must thus be essentially rooted in pedagogical criteria. Teachers must therefore engage in a critical reflection of the action to be carried out, the most appropriate tools, how the contents are to be developed, what external resources are to be incorporated, and so on. The plan should be designed with targets in mind; however it currently appears that this model is being introduced without the necessary forethought (Marshall, 2011). The decisive and thoughtful adoption of this model generally depends on the initiative of individual teachers, given that sufficient resources are not usually available to allow for a correct pedagogical focus (Casanovas, 2010; Francis & Shannon, 2012; Graham, Woodfield, & Harrison, 2013).

2. Research Context

2.1 Face-to-Face Teaching

Traditionally, the mode of teaching followed in the Engineering degree is, and the interaction professor-student stays, restricted to classroom time. The Material Science subject counts with theoretical, problem solving and laboratory classes. For the keeping up with the subject matter taught, the students had at their disposal a collection of transparencies that the professor used in class, a book of problems that included the theoretical aspects needed to solve the exercises, a collection of solved problems and another with formulations so that the students practiced. For the laboratory classes, the instructions needed were given according to the material to be taught. The methodology was based on presentations and demonstrations, with the intent that through the questions posed during the class, the students would participate in the development of the class itself; the questions focused on the more difficult aspects, so that the students developed reflective learning processes, so that they developed a working hypothesis, gave meaning to the concepts that were being studied, constructed theories and searched for solutions to real-life work situations. Likewise, doubts and suggestions were resolved. The experiment showed that even taking into account the benefits that could be obtained, the degree of participation was low, the students showed a passive attitude and were limited to only taking notes of the explanations, which did not lead to the correct follow up or taking the maximum advantage of class time.

On the other hand, the faculty had the obligation to tend to the students in tutoring sessions for six hours a week. This length of time was used for resolving doubts that the students could have, advising so that they are able to optimally follow what was presented in class, exam review, and all the academic requirements or personal support that were needed. However, it should be noted that the use of this time by the students was very low, and was limited to resolving doubts on dates that were close to exam date and to attendance for review when the grades did not meet expectations.

The problems that were detected with time were the scarce dedication of the students in order to have their studies up to date, which implied scarce possibilities of passing the evaluation tests successfully, and the increased dropping of the class. After analyzing the situation, which was repeated every academic year, the need to modify the teaching methodology was determined, with the changes starting with the resources found in the Learning Management Systems (LMS), in this case WebCT, which will be described below.

2.2 Integration of Hybrid Learning

The elements of the teaching-learning process that were intended to be modified were: to ensure that the students acquired good study habits; increase the degree of interaction between the professor and the students, and among students themselves as well, to try trying to develop a collaborative learning environment. Likewise, to increase the student's motivation, as they could see how becoming more involved in their learning processes led to improved grades. Also, the development of basic skills, such as analysis, synthesis, elaboration of a hypothesis, evaluation of what was learned, and self-regulation of learning were targeted. The platform was used during the first quarter of the course (Sept-Jan period).

Before the start class, the students were advised to take the tests available on the platform in order to have available the materials that were going to be looked at in class, to prepare the content as indicated by the professor, make a note of the doubts that could appear during the learning process, and ask them in the adequate forum in the platform. And if they knew the answer or a resource that could be used to find the answer to a question asked by a classmate, to act collaboratively. During the class, a recommendation was made to express doubts that could appear, to answer the questions asked by the professor, take notes on the new information given in class, and do the activities that were set out. After class, an indication was made on the need to create a synthesis with all the information available, do the tasks that were asked for, re-organize all the content (notes from the platform and the class, information gathered from the forum, reading of the recommended articles,…), evaluate the knowledge acquired, express doubts that could appear, and actively participate in the discussion forums.

In order to achieve all the objectives cited, the content was designed in HTML format using the Dreamweaver software, which would posteriorly be implemented into WebCT. These were structured following the conceptual map of each of the didactic units and corresponding lessons, with the distinctive feature that the students only had direct access to the first lesson of each unit, and to access the rest, they had to take three tests that appeared at the end of each one of them.

The first test was a self-evaluation, and had as an objective the focusing of the student's attention to the elements that were thought to be more difficult to understand, and that should have brought to light the student's doubts. The second test had as a function the mastery of the concepts, of the elements that intervened in the definitions, of the individual characteristics of the building products being studied, as all of these implied the development of analytical and synthesis skills. The third test, once the student had acquired the basic concepts, placed the students in professional situations, to try to bring them closer to the reality of their future profession, and to the making of decisions from the economic, scientific and technical points of view, to increase motivation, and to develop creativity. The three tests given to the students were composed of a variable number of questions that the system chose randomly among those available in its database. The more tests taken, the more in-depth was the coverage of the subject matter in every lesson done, and the greater degree of knowledge of what the student really understood, as the system provided the scores immediately. When the student passed each test, the next lesson became available, and so on. If at any time the student failed one of the tests, the following lessons that were already visible would automatically close, until the failed test was passed.

All the tests designed were integrated into the curriculum, and subjected to the objectives and skills that the students had to attain, with the final aim being more formative than summative; it was continuous as well, as it informed on the advances that were being produced through time. The tests were considered to be a permanent support for training and verification of the successes attained. They also allowed for feedback for the students, so that they could check on their own progress, and they also allowed the professor to check the student's progress or difficulties, allowing for continuous monitoring and advising using the tools available in WebCT.

If the content and their organization are important, so are the learning resources that are made available to the students in a context of flexible learning, adapted to the characteristics and needs from each one of them. For this, they had a virtual library available, organized by didactic unit and subclassified following a conceptual map of each theme. The students had 104 bibliographic references available at the university's library; 75 direct-access videos, 325 articles online, and 75 webpage links. These resources were provided in order to satisfy the student's training/learning interests beyond what was going to be needed for the exam, increasing curiosity and the wish to learn and ask freely

As for the communication tools, email and forums acquired important roles in the blended-learning model. Email was destined for personal communication, with a commitment to answer within 48 hours. Through it, the students informed the professors about any incidents that could appear during their study sessions, or the professors themselves, when looking at each student's trajectory, would communicate with them making observations to improve their performance, or to acknowledge the successes reached. Email was not used at any time to resolve academic doubts, as these were resolved in the forums.

The philosophy used for the functioning of the forum was to maximize student participation, so that the answers were to be given by the students themselves, although the process was supervised by the professor in charge. The objective was to develop a collaborative learning methodology. The forum was organized hierarchically, in first place by didactic units and in second place by lessons. The students were told that they would be the main actors, and that between them they had to build knowledge. The role of the professors was to invigorate the work in the forum, advise students, re-direct discussions, promote a satisfactory work environment, and congratulate for the contributions given.

2.3 The Return to Face-to-Face Teaching

As mentioned before, the addition of the educational platform was done to try to solve serious problems such as low performance and a high rate of dropouts. To verify the supposed positive effect that this new environment could have had, the face-to-face traditional method was implemented on the second quarter with the same students. The resistance of the student to returning to the traditional system should be noted.

3. Method

3.1 Objectives and Hypotheses

The aim of this study was to determine the effects of a blended-learning programme on students' performance compared to traditional teaching. The following objectives and hypotheses were therefore defined:

Objective 1: To see whether there was a relationship between students' academic performance and the methodology used (blended-learning or face-to-face).

Hypothesis 1: there is a correlation between the marks in the different preparatory tests for the teaching units in the first term, and the marks in the classroom-based evaluation:

> H_0: there is no correlation between the marks in the preparatory tests for the units and the marks obtained in the corresponding classroom-based evaluation.

Hypothesis 2: in the experimental group, there will be differences between the marks in the first and second term in view of the fact that different teaching methods are used:

> H_0: there are no significant differences between the marks in the first and second terms.

Objective 2: to verify the relationship between the amount the students used the evaluation tool and their academic performance.

Hypothesis 3: the students' performance in the Materials Science course in the Architectural Engineering degree was related to the amount they used the preparatory tests:

> H_0: there are no significant differences in the students' performance in the course in relation to the amount they use the preparatory tests.

3.2 Design

The choice of the method to be used in an educational research project depends on the nature of the hypotheses. The hypotheses proposed here were designed to analyse the influence of the methodology, and the relationships between variables; we therefore selected a quasi-experimental methodological design with two non-equivalent groups (Cohen & Manion, 1990), supplemented by the use of a descriptive and correlational method.

3.3 Participants

The control group comprised 197 students at the start of the course and for whom there were demographic data and marks. In this sample, 67 (34.0%) were women and 130 (66.0%) men. The experimental group comprised 212 students, of whom 69 (32.5%) were women and 143 (67.5%) men. The age distribution is shown in Table 1.

Table 1. Age distribution

Age	Control group		Experimental group	
	N	%	*N*	%
18-20	129	65.48	130	61.30
21-15	57	28.93	53	25.00
26-30	6	3.05	19	8.98
> 30	5	2.54	10	4.72

3.4 Instruments

The data for the analysis of the control group were obtained from the university's register of marks; and the data for the experimental group from the Evaluation, Grade Book and Follow-up options in WebCT for the first term, and from the university's register of marks for the second term.

3.5 Data Analysis

The SPSS version 17 computer package was used. In order to address hypothesis 1, a correlation study was done using Pearson's coefficient. For hypothesis 2, Student's t-test was used for two related samples in order to compare the averages of the marks according to the two teaching methodologies used. For hypothesis 3, an analysis of variance (ANOVA) was used to determine whether there were any differences between the marks, based on three different amounts of use of the evaluation tests in the WebCT platform; the scores from unit 2 did not meet normality assumptions, so the non-parametric Kruskal-Wallis test was applied. In all the tests, a confidence level of 95% was established (α=.05).

4. Results

4.1 Correlation Study in the Control Group (First Year)

The Pearson's correlation coefficient between the marks of the control group in the first and second terms is shown below (Table 2). It should be noted that throughout the year, the teaching was only classroom-based.

Table 2. Pearson's correlation between terms in the control group

Combination of pairs	*N*	Pearson $\wp_{x,y}$	*p*
First term mark–Second term mark	135	.618**	.000

**. The correlation is significant to p=.01 (bilateral).

The analysis of the coefficient between the marks in the two terms revealed a statistically significant positive correlation, Pearson's r (*N*=135)=.618, *p*=.000, with a large effect size, which indicates that there is a correlation between both marks.

In order to determine whether there were differences between the averages of the two terms, Student's t-test was done for the two related samples, with no significant differences found between the average marks obtained by the control group in the first term (*M*=4.22) and the average marks for the second term (*M*=4.10), *t*(134)= .718, *p*=.474.

Student's t-test confirmed that there were no significant differences between the marks for the first and second terms in the control group under the same teaching methodology.

4.2 The Experimental Group in the First Phase: Using the Platform as a Resource (Second Year)

As indicated above, a classroom-based test was carried out at the end of each unit in order to verify the knowledge acquired by the students, in this case using WebCT. It is worth noting the findings. The results indicate that the number of no-shows increased as the term advanced; except in Unit-1 (fr=2), no student obtained the top mark ($9 \leq M \leq 10$ points); most students who passed the classroom-based tests did so with a pass mark ($5 \leq M < 7$ points); and generally speaking, the percentages of no-shows and failures predominated as compared to passes, regardless of the mark ($5 \leq M < 7$, $7 \leq M < 9$, $9 \leq M \leq 10$ points).

The students' performance based on the percentage of available tests taken is analysed below.

Table 3. Results according to tests taken

% of tests	Unit-1(*)			Unit-2(**)			Unit-3(*)		
	% M≥5	% Fail	% No show	% M≥5	% Fail	% No show	% M≥5	% Fail	% No show
%=100	24.06	7.08	0	10.29	11.76	5.15	31.13	20.75	.94
80>%<100	5.19	2.82	0	2.94	2.21	.74	.47	6.13	0
60>%<80	8.49	6.14	.94	.74	4.42	0	0	3.31	.47
40>%<60	4.71	11.8	3.77	2.21	13.97	4.42	0	.47	.94
20>%<40	.47	4.72	2.36	0	2.21	.74	0	.47	0
0>%<20	0	5.19	7.08	0	2.21	4.41	0	1.41	3.31
%=0	0	.47	4.72	0	.74	30.88	0	.94	29.25

(*) of enrolled; (**) of eligible=enrolled–76; M=mark

Table 3 shows that the likelihood of obtaining a pass mark increased as the number of tests taken increased, as indicated by the percentage of passes in the total number of students taking all the tests: 24.06% in Unit-1 and 31.13% in Unit-3. Unit-2 shows a different situation; of the 212 students monitored, 76 were not required to take part in the classroom-based test as they were considered to have obtained a high enough academic level through the tests on the platform, the tasks, and through their participation in the classroom and/or in the discussion forums created. In this unit we see a shift in the trajectory initiated in Unit-1, where the greater the number of tests taken, the greater the likelihood of passing. In this unit this was no longer a valid criterion, given that the number of students who took all the tests and failed (11.76%) was greater than the number of those who passed (10.29%). The trend whereby the students with the lowest showing up rate were the ones who took the fewest tests continued unchanged. Unit 3 shows the same situation as in Unit-1, in which the greater the number of tests taken, the higher the chances of passing, as indicated above. In this case 31.13% of the students who completed all the tests passed, as opposed to 20.75% who failed. At the opposite end of the spectrum, coinciding with the other two units analysed, the students who had taken the lowest number of tests were more likely to fail or to not show.

Below is an analysis of the relationship between the amount of use of the preparatory tests and performance. Three user groups were established based on the number of release and evaluation tests taken: low, where the number of tests taken was between the 0 and the 33^{th}; intermediate: the number of tests was between the 33^{th} percentile and 67^{th} percentile; and high: the number of tests was between the 67^{th} percentile and the maximum of the tests taken.

Table 4. Normality test of the marks according to use of evaluations

Unit	Use of tests	Kolmogorov-Smirnov		
		Statistics	gl	*p*
	Low	.104	41	.200*
1	*Med*	.080	61	.200*
	High	.104	68	.065
	Low	.130	27	.200*
2	*Med*	.150	59	.002
	High	.244	62	.000
	Low	.112	21	.200*
3	*Med*	.079	50	.200*
	High	.080	66	.200*

*. This is a lower limit then the true significance.

In the marks for Unit 2, the Kolmogorov-Smirnov normality test (Table 4) indicated that the normal distribution was not fulfilled, as there were some categories in the variable group "amount of use of evaluations" that had a $p<.05$. In contrast, the marks for Units 1 and 3 did fulfil the assumption of normality as they had values of $p>.05$ in all three categories.

Table 5 shows the averages of the students' marks in the three units according to the use of the evaluation test, and the mean ranks of the units which did not fulfil the assumption of normality and for which the Kruskal-Wallis test was used.

Table 5. Descriptive statistics of marks based on amount of use of the evaluations

Unit	Use of tests	Descriptive statistics			Mean rank
		N	*M*	Std. deviation	
	Low	41	3.33	2.18	
1	*Intermediate*	61	4.71	2.05	
	High	68	5.88	1.63	
	Low	27	3.21	2.06	35.31
2	*Intermediate*	59	5.06	2.29	67.91
	High	62	6.71	1.30	97.84
	Low	21	4.13	1.72	
3	*Intermediate*	50	4.61	2.03	
	High	66	5.20	1.55	

The fulfilment of the assumption of normality in the marks for Units-1 and 3 allowed for the use of the analysis of variance (ANOVA) (Table 6), whereas the nonparametric Kruskal-Wallis test was used for the marks in Unit-2 (Table 7).

Table 6. ANOVA for marks grouped by amount of use of evaluations

Unit	Levene's test		ANOVA							
			Snedecor				Welch			
	F	Sig	*F*	gl-1	gl-2	Sig	*F*	gl-1	gl-2	Sig
1	2.66	.07	22.73	2	167	.000	22.39	2	93.54	.00
3	2.05	.13	3.47	2	134	.034	3.78	2	53.51	.03

Levene's test in the ANOVA of the marks for Units 1 and 3 gave a significance of p=.07, p=.13 respectively, which –as they were greater than .05– indicated that the assumption of homoscedasticity was fulfilled; we thus used Snedecor's ANOVA F-test, which revealed significant differences:

- In the marks for Unit-1: between the average of the lowest use of the tests (M=3.33; s=2.18), the intermediate use (M=4.71; s=2.05) and the highest use (M=5.88; s=1.63), F(2.17)= 2.73, p=.00; Tukey's *post hoc* HSD test confirmed that the significance was due to the differences between the lowest and intermediate use (p=.001), lowest and highest (p=.000) and between the intermediate and highest use (p=.002);
- In the marks for Unit 3: between the average for the lowest use of the tests (M=4.13; s=1.72), the intermediate use (M=4.62; s=2.03) and the highest use (M=5.20; s=1.55), F(2.13)=3.47, p=.034: Tukey's *post hoc* HSD test confirmed that the significance was due to differences between the lowest and highest use (p=.045).

Table 7. Kruskal-Wallis test for marks grouped according to use of tests

Unit	*N*	Contrast statistics		
		Chi squared	gl	Significance
2	148	42.34	2	.000

The nonparametric Kruskal-Wallis test indicated that there were significant differences in the marks for Unit-2 between the mean ranks of the lowest use (*MR*=35.31), the intermediate use (*MR*=67.91) and the highest use (*MR*=97.84), $X^2(2, N=148)=42.34$, *p*=.000.

Thus the null hypothesis number 3 is rejected: "there are no significant differences in the students' performance in the Materials Science course in the Architectural Engineering degree in relation to the amount they use the preparatory tests" in the three units of the first term.

4.3 The Experimental Group in the Second Phase: Without Using the Platform as a Resource

The number of no-shows is higher at the end of the term. Except in Unit-7 (fr=7), no student obtained the maximum mark (9≤M≤10 points); most of the students who passed the classroom-based test obtained a mark between 5≤M<7 points, except in Unit-7, where the number of students who obtained this mark was the same as those who obtained marks in the interval 7≤M<9 points. If the results were grouped into no-shows plus fails (fr=155), compared to those who passed the tests regardless of the mark (fr=67), it can be seen that the highest frequencies were found in the first group.

4.3.1 Correlation Study in the Experimental Group

The results below show the relationship between the classroom-based evaluation and the preparatory tests. This was done by establishing combinations between the marks obtained in the evaluation for each unit and the results of the various tests carried out in WebCT for Units 1, 2 and 3. Only Unit-2 had release tests.

Table 8. Pearson's correlation for pairs between tests

Combination of pairs	*N*	Pearson $\wp_{x,y}$	*p*
Unit-1			
Release test average–average of WebCT evaluations	125	.540**	.000
Classroom evaluation–release test average	170	.653**	.000
Classroom evaluation–evaluation average	119	.400**	.000
Classroom evaluation–WebCT test average	170	.651**	.000
Unit-2			
Classroom evaluation–WebCT test average	72	.467**	.000
Unit-3			
Release test average–average of WebCT evaluations	119	.454**	.000
Classroom evaluation–release test average	135	.367**	.000
Classroom evaluation–evaluation average	117	.383**	.000
Classroom evaluation–WebCT test average	135	.468**	.000

**.The correlation is significant to level .01 (bilateral).

When analyzing Peason's correlation coefficents (Table 8) of the means from the different tests, there were statistically-significant positive correlations in the following cases, classified by the size of the effect.

- Medium effect size:
  - The mark for the classroom-based evaluation and the average of the marks obtained in the evaluation tests carried out in WebCT for Unit-1, Pearson's r (*N*=119)=.400, *p*=.000.

- The mark for the classroom-based evaluation and the average of the marks obtained in all the tests carried out in the platform WebCT in Unit-2, Pearson's r (*N*=72)=.467; *p*=.000.
- The average of the marks obtained in the release tests and the average of the marks obtained in the evaluation test for Unit-3, Pearson's r (*N*=119)=.454, *p*=.000.
- The mark for the classroom-based evaluation and the average of the marks obtained in the release tests carried out in WebCT for Unit-3, Pearson's r (*N*=135)=.367, *p*=.000.
- The mark for the classroom-based evaluation and the average of the marks obtained in the evaluation tests carried out in WebCT for Unit-3, Pearson's r (*N*=117)= .383, *p*= .000.
- The mark for the classroom-based evaluation and the average of the marks obtained in all the tests carried out in WebCT (releases and evaluations) for teaching Unit-3, Pearson's r (*N*=135)=.468, *p*=.000.

- Large effect size:
  - The average of the marks obtained in the release tests and the average of the marks obtained in the classroom-based evaluation tests for Unit-1, Pearson's r (*N*=125)=.540, *p*=.000,
  - The mark for the classroom-based evaluation and the average of the marks obtained in the release tests carried out in WebCT for Unit-1, Pearson's r (*N*=170)=.653, *p*=.000,
  - The mark for the classroom-based evaluation and the average of the marks obtained in all the tests carried out in WebCT (releases and evaluations) for Unit 1, Pearson's r (*N*=170)=.651, *p*=.000.

Pearson's correlation coefficient confirmed that there was a correlation between the students' marks in the different preparatory test for Units 1, 2 and 3. Therefore, the null hypothesis number 1 is rejected: "There is no correlation between the marks in the preparatory tests for the units and the marks obtained in the corresponding classroom-based evaluations".

The results of academic performance obtained in the two terms indicated that the means of the marks were slightly higher in the first term (*M*=4.26) than in the second (*M*=3.93). In both terms, the medians were higher than the mean values, showing that over 50% had a higher mark than the respective mean values. Moreover the standard deviation indicated that the marks were more homogeneous in the second term (*s*=1.70) than in the first (*s*=2.27).

Table 9. Descriptive statistics of the marks in each unit

Statistic	First term			Second term			
	Unit-1	Unit-2	Unit-3	Unit-4	Unit-5	Unit-6	Unit-7
Mean	4.83	5.42	4.82	4.31	3.92	3.32	6.21
Median	5.15	6.48	4.95	4.25	4.00	3.00	6.40
Mode	4.00[a]	7.30	4.17	5.00	4.00	1.40	6.40
Std. deviation	2.16	2.27	1.79	1.43	1.83	1.72	1.88
Variance	4.66	5.17	3.21	2.06	3.36	2.95	3.54

a. There are various modes. The lowest value is shown.

The unit with the highest mean value was Unit-7 (*M*=6.21), while Unit 6 (*M*=3.32) had the lowest. The value of all the medians from all the units, except 4 and 6, was higher than their means, indicating that over 50% of the marks produced were above the mean values shown in Table 9. An analysis of the standard deviations showed that the unit with the least homogeneity in marks was Unit-2 (*s*=2.27), while Unit-3 had the most homogeneity (*s*=1.43).

The Pearson's correlation coefficient between the marks of the experimental group in the first and second terms is shown below (Table 10).

Table 10. Pearson's correlation between terms in the experimental group

Combination of pairs	N	Pearson $\wp_{x,y}$	p
First term mark–Second term mark	167	.624**	.000

**. The correlation is significant to level .01 (bilateral).

The analysis of the coefficient between the marks in the two terms revealed a statistically significant positive correlation, Pearson's r (N=167)=.624, p=.000, with a large effect size, indicating that there was a correlation between both marks.

To determine whether there were differences between the means of the two terms, a Student's t-test was done for two related samples, revealing significant differences between the average of the marks obtained in the first (M=4.51) and second (M=3.92) terms, $t(166)=4.402$, p=.000 with a small effect size d=.30.

Student's t-test allowed us to reject the null hypothesis number 2: "There are no significant differences between the marks in the first and second terms".

5. Discussion

As indicated in the results section, no significant differences were found in the control group, whereas significant differences in the experimental group were detected between the marks in favour of the blended-learning methodology. We can thus confirm that in this research context the use of this method improved the students' performance. Our findings in the technical area were similar to those of Cortizo et al. (2010), Domingo-Calabuig and Sentieri-Omarrementeria (2011), Jara et al. (2011), Méndez and González (2010) among others.

This improvement can be attributed to the following causes:

- The training resources the students had at their disposal, which allowed them to assess their level of knowledge and their learning progress, and to establish a correct procedure for self-regulation and monitoring (Chandra & Watters, 2012; Jia, Chen, Ding & Ruan, 2012). The students who obtained the best results were those who had the greatest interaction with the system (Lee et al., 2013; Spanjers et al., 2015).
- The interaction with the teacher-tutor, which was far greater than in traditional teaching. It should be noted that the personal tutoring sessions were underused by both the control and experimental groups. However, when the students were allowed to use the communication tools used in this study, there was a significant increase in consultations with the teacher-tutor. This can thus be considered to be a major factor in improving the results (Chandra & Watters, 2012; Mahle, 2011; Vázquez-Martínez & Alducin-Ochoa, 2014). This interaction favoured student satisfaction (Georgsen & Lovstad, 2014; Deschacht & Goeman, 2015; Spanjers et al., 2015; Zacharis, 2015).
- Peer interaction, with the development of very important collaborative practices such as providing mutual help, and the creation of several forums in order to resolve the queries posed by classmates (Georgsen & Lovstad, 2014; Zacharis, 2015).
- As a result of these factors, and in order to respond as correctly as possible to the queries posed by other classmates, the student's reasoning processes and arguments throughout the four-month period were observed to move progressively towards a higher intellectual level, thus providing evidence of an improved understanding of the contents and capacity for critical thought (Güzer & Caner, 2014; Nizkodubov & Evseeva, 2015; Yen & Lee, 2011).
- The students were aware that all the work done outside the classroom was assessed as part of the process of continuous and formative evaluation, and this spurred them to make greater efforts. However, this was done under the premise that all the students needed to work at their own pace, and the platform was therefore adapted to the progress of every single student, in an individualised and flexible process of teaching-learning (Adileh, 2012; Alducin-Ochoa & Vázquez-Martínez, 2014; Zacharis, 2015).

The results achieved indicate that the students that showed a better performance with WebCT (in this particular scenario, dealing with knowledge tests) were those who more-frequently used the diverse materials that were available to them (Francis & Shannon, 2013). The WebCT monitoring tool proved that, consequently, they were also the ones with higher possibilities of success. It must be noted that this success was related to the flexibility offered by WebCT (Sivakuman, Namasivayam, Al-Atabi & Ramesh, 2013; Tempelaar, Rienties, Giesbers, 2015; Zacharis, 2015), because this environment could be adapted to the students' particular circumstances and needs, since it allowed for the incorporation of a great diversity of tools to cover individual needs, and at the same time it was more focused on students (Adileh, 2012; Chandra & Watters, 2012; Deschacht & Goeman, 2015; Vasileva-Stojanovska, Malinovski, Vasileva, Jovevski, & Trajkovik, 2015; Siemens, 2013; Zacharis, 2015). Nevertheless, as pointed out by Maki, Maki, Patterson and Whittaker (2000), those students that followed online courses showed a better performance when they were forced to interact with the material. Therefore, we must design new strategies in which students are required to achieve a compulsory minimum level of performance. In this way we will be able to check whether the desired results are achieved within this context.

This type of teaching method requires that the students develop a significant, individual, active and interactive attitude, since the results will depend on their own ability to self-regulate their own learning processes and on the perceptions they maintain as well. Therefore, students would need to choose their own learning paths (like the one offered by the experience we are dealing with) at the same time they acquire further responsibility regarding the learning itineraries they have selected. In other words, the student must become an active agent in the learning process (Deschacht & Goeman, 2015; Yen & Lee, 2011). The improvement in the students' performance we have identified might be motivated by the fact that students noticed changes in the way they studied as well as due to the new tools they were given. Thanks to these two factors, students face exams on-site with a greater level of confidence. As a result, their motivation was increased and they wished to keep working hard.

The limitations of this study include the scarcity of studies in the area of Architecture and Engineering that could be used to compare and contrast the results found, and this situation is even more noticeable in the university degree studied here. Likewise, the fact that the student's learning style and focus were not studied is a limitation as well, as these aspects could have influenced the results shown. It is interesting that the students showed resistance to work using a blended learning method when they understood that their work was going to be constantly supervised, that it would mean a greater dedication as compared to the traditional methodology, that with the means available they would be directly responsible for their academic results, and that the class time would no longer be used fundamentaly for the presentation of the class material by the professor.

We consider the findings of this research to be important; however it is necessary to continue to explore aspects such as understanding students' perception and performance in educational platforms, determining the advantages and disadvantages inherent in this model, and refocusing the study from the perspective of students' learning styles and approaches in order to gain a greater insight into the learning processes involved in blended learning.

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