

Students' Perceptions and Performance with Traditional vs. Blended Learning Methods in an Industrial Plants Course*

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With the advent of information and communication technologies (ICTs) learning strategies and methods have changed. Academics and students are also changing the way they teach and learn in an effort to adapt to these new methods. The aim of this paper is to compare students' perception of traditional vs. blended learning methods in the Industrial Plants course, which is part of the Degree in Industrial Engineering and Scheduling taught at the Technical University of Catalonia (UPC). A questionnaire was developed and given out to 163 students enrolled in the course, over a period of two academic years (2004–2005 and 2005–2006). The findings of this study provide practical guidelines for the implementation of new teaching methods.

Keywords: blended learning; learning methods; assessment

INTRODUCTION

IN THE 2000–2001 ACADEMIC YEAR, the School of Industrial and Aeronautical Engineering of Terrassa (ETSEIAT), which belongs to the Technical University of Catalonia (UPC), began to teach the second cycle Degree in Industrial Engineering and Scheduling in a blended learning modality. Evidently, there were changes in the way the academics and students on this degree course taught and learned, and feedback was collected on how this new teaching methodology was perceived and how it compared with the traditional, face-to-face modality. This feedback provided practical guidelines for improving the implementation of the blended learning modality.

DIFFERENCES BETWEEN TRADITIONAL AND BLENDED LEARNING / LITERATURE REVIEW

Blended learning can be distinguished from classroom and online learning. The real test of blended learning is the effective integration of face-to-face learning with online learning in such a way as to ensure that it is not just an accessory to the dominant approach or method. It involves a fundamental reconceptualisation and reorganisation of teaching and learning dynamics, starting with specific contextual needs and contingencies (e.g., discipline, developmental level, and resources).

In blended learning, there is considerable intuitive appeal to the concept of integrating the strengths of synchronous and asynchronous learn-

ing activities. Its implementation constitutes a considerable challenge, because of the virtually limitless design possibilities and its applicability to so many contexts [1]. Focusing on the properties of the Internet, much of the success of blended learning experiences, and the satisfaction to be gained from them, can be attributed to the interactive capabilities of information and communication technologies (ICTs) [2]. Closer examination reveals the ability of asynchronous ICTs to facilitate simultaneously independent and collaborative learning experiences, that is, learners may be independent in time and space, and yet together.

With the combination of synchronous verbal and asynchronous written communication in the context of a cohesive community of inquiry, blended learning offers a distinct advantage in supporting higher levels of learning through critical discourse and reflection. Because it is relatively new, and considering that satisfaction is a critical factor in establishing long-term client relationships [3], students' perception of this new method is the basis for improving its implementation.

BACKGROUND

The blended learning modality of the Degree in Industrial Engineering and Scheduling is basically addressed to students whose profiles are substantially different from those of students enrolled in traditional courses. Blended learning students are generally young diploma-holders in engineering (mechanical, electrical, etc.) who are immersed in the working world and wish to improve their

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knowledge of business administration in order to get a better job. The main differences between the traditional and blended learning students on this degree course are as follows.

The blended learning students are more likely to be in employment than traditional students. This means that they have less time to devote to their courses but they are also that more motivated and prepared to dedicate their leisure time to accomplishing their goals.

Students are younger in the traditional modality. Most of them have just finished the first cycle so they are still studying. Blended learning students have generally left academia a few years previously and return to university after a period of academic inactivity. They are disadvantaged in the sense that they are unused to studying and must adapt to new daily routines.

Nonetheless, graduates of the degree course have the same profile regardless of the modality they choose. They are all qualified as industrial schedulers and thus have acquired the tools they need to apply scientific knowledge to new devices and to developing systems and protocols in the industrial world, as well as a broad understanding of organisational problems.

It is very important to take into account the aforementioned differences in student profiles when one is establishing strategies for the blended learning modality, particularly in defining an itinerary and designing the teaching materials that will help students learn. The blended learning degree spans three academic years and six semesters (25 credits per semester), while the face-to-face degree spans two academic years and four semesters (37.5 credits per semester). This difference is basically due to the fact that there are fewer face-to-face sessions on the blended learning course because students are supposed to work at home using the virtual campus. This allows blended learning students to combine employment with education.

The timetable for the traditional degree course is from 3 p. m. to 9 p. m. (25 hours a week in total). On the blended learning degree course, face-to-face sessions are held twice a week, from 5.30 p. m. to 9.30 p. m. (8 hours a week in total). The degree course spans 15 weeks. Blended learning students must attend at least 50% of the face-to-face sessions, to ensure that the knowledge they acquire takes root and to prevent them from dropping out of the course, which can occur if they feel they lack support. Because there are more applications than entry places, in the admissions procedure particular importance is given to candidates' academic records, CVs and current professional situation.

Industrial Plants is a six-credit course that is part of the Degree in Industrial Engineering and Scheduling. Of these six credits, three are theory-based and three are laboratory-based. The aim of this course is to provide basic knowledge of the relationship between economic activities—industry and trade—and the region in which an industrial plant is located, focusing on the need for choosing

an appropriate location and the legal requirements the plant must satisfy. The course provides the know-how that will enable the industrial scheduler to analyse, define and communicate the requirements for a building in a clear, concise and comprehensive way and to choose the overall best of several design and construction solutions.

The course is divided into six modules. Module I focuses on the complexity of a new industrial location and gives a general vision of all the systems that contribute to it. Module II provides information on generating an industrial process layout. Modules III and IV describe the various materials and facilities that an engineer may find in a new building. Module V is on industrial urban planning and Module VI considers the main fire protection standards for industrial buildings. Students enrolled in the traditional degree course and those taking the blended learning degree course are required to carry out a project involving the implementation of an industrial process and in which the knowledge acquired in each module is applied.

On the blended learning degree course, students work with their partners in a group at the face-to-face sessions. For the aforementioned project, they interact face to face and communicate online (via Atenea, the virtual campus). They choose an industrial process and define its characteristics and requirements in terms of distribution, spaces, additional facilities, building construction, etc. They team up in groups of five and deliver the final implementation. Any doubts are generally solved using Atenea, although at the face-to-face sessions questions are answered, doubts clarified and examples provided on specific parts of the project. Students are obliged to work on their project over the entire duration of the degree course, which ensures that they receive feedback on each part.

In the traditional modality, students have four hours of class a week (60 hours per degree course), two of which are devoted to the course content and two of which focus on the project's implementation, practice, etc. In the blended learning modality, there are five face-to-face sessions in total (10 hours per course). Only the most difficult topics are explored at these sessions—the rest of the course is taught in Atenea by means of special documentation, online tests, e-discussions, etc. Assessment follows the same system for both modalities: a theory part accounts for 65% of the final mark and the implementation project makes up 35% of the final mark.

CASE STUDY

Students from the two modalities took the Industrial Plants course at the same time. The two groups of students performed the same tasks, followed the same syllabus, carried out the same implementation project, sat the same examination, etc. The teaching methods were of course different. All classes in the traditional modality were face-to-

face classes, while in blended learning modality there were several face-to-face sessions, in addition to the content provided via Atenea, the digital campus that instructors and students can access from any computer with an Internet connection.

Using this platform, students can share, upload and download documentation, consult the course syllabus and timetable and their marks, put questions to the instructor and chat to other students. The most important aspect is that this environment enables instructors to offer students their support, follow their learning processes and assess their progress. In the traditional modality, the lecturer acts as the conveyor of knowledge, while in the blended learning modality the lecturer acts as an instructor who provides guidance, encourages students to work independently and participates in online communities, telephone conferences and live meetings, etc.

The comparison between traditional and blended learning modalities of the Case Study is given in Table 1.

METHOD

This study evaluates students' perception of blended learning vs. traditional learning methods in the Industrial Plants course, which is part of the Degree in Industrial Engineering and Scheduling taught at UPC. Opinions are also evaluated in the light of students' results. The findings of this study provide practical guidelines for improving the implementation of blended learning.

Sample selection

The survey was carried out in four semesters over a period of two academic years (2004–2005 and 2005–2006) on 174 students. Students were asked to fill out the questionnaire on the day of the final examination, so those students who had dropped out of the course were not included in the survey (11 students in total). Therefore, the sample comprised 163 students and the response rate was 94%. Male students accounted for 80% of the respondents.

Data collection/Survey tools

A questionnaire was designed to obtain information on student satisfaction and to determine student opinions on key elements of the course,

such as collaborative learning and group work. It was based on the Student Evaluation of Educational Quality (SEEQ) [4] method.

SEEQ is an instrument used to obtain student feedback on teaching and to develop teaching quality through reflective practice. It provides an empirical basis on which to evaluate teaching; at the end of a semester, it can be used to generate a profile of teaching performance.

SEEQ recognises the complex and multidimensional nature of teaching and aims to provide feedback on teaching rather than on content. The questionnaire contains questions that in combination provide indicators of teaching effectiveness in nine key areas, and an overall rating.

- Core factors: Learning/academic value, Instructor enthusiasm, Individual Rapport, Examinations/grading, Overall Rating
- Additional factors: Organisation/clarity, Breadth of coverage, Group interaction, Assignment readings, Workload/difficulty

SEEQ is a comprehensive questionnaire whose validity and reliability have been upheld by a large amount of research. The items in the questionnaire consider different aspects of teaching, which facilitates the identification of areas for improvement and comparison between different learning methods. Moreover, it is widely used, which facilitates comparison between institutions. Obviously, the SEEQ questionnaire suffers from the same problems as any other: it is not suitable for all possible courses or ways of teaching. For instance, the SEEQ questionnaire is not suited to e-learning and blended learning. Therefore, various questionnaires for evaluating e-learning were consulted, such as a university blended learning questionnaire [5], a questionnaire for the evaluation of a collaborative virtual learning environment [6] and the WINDS questionnaire [7], with the aim of adapting the SEEQ questionnaire to our specific scenario.

The final questionnaire referred to the following topics:

- Learning
- Organisation
- Interaction with the instructor
- Interaction with other students
- Evaluation
- Difficulty
- Others

Table 1 Similarities and differences between traditional and blended learning modalities (Case Study)

	Traditional	Blended learning
Teaching method	Face-to-face classes	Face-to-face sessions + Virtual platform (Atenea)
Type of students	Just finished first cycle studies— Only studying	In employment—Have less time— More motivated
Timetable	60 face-to-face hours/course	10 face-to-face hours/course
Contents	The same profile	
Evaluation system	The same (65% exam + 35% project)	

In order to assess these topics, an item pool was created using items derived from the literature; this pool was validated and tested for reliability.

Of all the items that were available, 33 were selected. A five-point Likert scale (5 = strongly agree, 4 = agree, 3 = neither agree nor disagree, 2 = disagree, 1 = strongly disagree) was used to evaluate students' responses to the questions (see Appendix 1 for the full questionnaire).

Data analysis

The questions in the survey allowed quantitative data to be collected from students. Descriptive statistics were used to analyse the quantitative data collected using closed questions and to calculate the mean and standard deviation of the students' responses.

The questionnaire was handed out at the end of the course to all the students who took part during the 2004–2005 and 2005–2006 academic years. The questionnaire was given to students enrolled in the face-to-face course for the first semester of the 2004–2005 academic year (N = 26) and for the first semester of the 2005–2006 academic year (N = 30). It was also handed out to students enrolled in the blended learning course for the second semester of the 2004–2005 academic year (N = 39) and in the second semester of the 2005–2006 academic year (N = 68). The results and analysis of the questionnaire are presented and discussed in the following section.

ANALYSIS

Analysis of homogeneity

The results of the student surveys (mean and variance) for the first semester of the 2004 and 2005 courses (traditional modality) and for the second semester of the 2004 and 2005 courses (blended learning modality) were used to test the homogeneity of the two semester samples with the aim of joining them to extract conclusions. Table 2 compares the traditional and blended learning modalities (mean and variance) and Table 3 summarizes this comparison in the different areas of study.

A homogeneity test verifies whether the populations can be considered equal.

- A_i : 40 populations (each of the questions in the questionnaire)
- B_j : 2 partitions (each of the samples for the different years)
- p_{ij} : the probability that an element of A_i belongs to a B_j modality. The hypothesis to be verified is
- H_0 : $p_{1j} = p_{2j}$; $j = 1, 2, 3, \dots, 40$
- n_{ij} : the experimental effectiveness of line i and column j
- n_i : total of the i -esim line
- n_j : total of the j -esim column
- n : sum total 238.38
- t_{ij} : estimation of theoretical effectiveness

$$t_{ij} = \frac{n_i \cdot n_j}{n}; \quad W = \chi^2 = \sum_i \sum_j \frac{(n_{ij} - t_{ij})^2}{t_{ij}}$$

$$\nu = (k-1)(r-1); C = \{W \geq \chi^2_\alpha\}; \alpha = 0.05; \chi^2 = 55.76; \nu = 39$$

For the traditional modality sample: $W = 0.60 < 55.76$

For the blended learning modality sample: $W = 0.53 < 55.76$

Both of the experimental values above belong in the acceptance region and the homogeneity hypothesis is accepted: the two samples from different years for the traditional modality represent populations with identical distribution and the two samples from different years for the blended learning modality also represent populations with identical distribution.

The homogeneity test of the two samples shows that there is no difference in the response variable between any of the two years' surveys. The two years' data sets were combined for further analysis in order to increase the power of the statistical test and the possibility of studying higher order interaction between the predictor variables.

Regression analysis

To obtain the results and compare the traditional and blended learning modalities it is important to explore the relationships between variables such as gender, age, professional situation and year of graduation.

All the variables analysed were significant ($p > 0.05$); therefore, the results of evaluating the variables in each area of the survey are analysed in the following paragraphs.

RESULTS

The results of the questionnaire are discussed in view of the different sections of the questionnaire: Learning, Organisation, Interaction with the instructor, Interaction with other students, Evaluation, Difficulty and Others. No conclusions were drawn with regard to the students' professional situations (students, students who are employed or employees who are students), because the majority of students on the face-to-face course (62%) were exclusively studying and the majority of students on the blended learning course were employed (82%). Therefore, a comparison would not be homogeneous. The results and analysis between men and women showed that there is no substantial difference between male and female students in either the traditional or the blended learning modality.

LEARNING

The first five questions in the survey are related to the information in the 'Learning' section. Both

Table 2 Comparison between traditional and blended learning modalities

	Traditional (N = 56)					Blended learning (N = 107)									
	Mean (M)	Var.	Percentage of respondents					Mean (M)	Var.	Percentage of respondents					
			Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree			Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	
			1	2	3	4	5				1	2	3	4	5
1	3.84	0.28	0	4	18	70	9	3.79	0.58	0	3	26	61	10	
2	3.95	0.84	0	2	7	55	36	4.03	0.53	0	3	16	57	24	
3	3.74	0.71	0	7	38	43	13	3.81	0.36	0	2	32	50	17	
4	3.79	0.27	0	0	27	59	14	3.72	0.31	0	4	26	64	6	
5	3.58	1.43	5	18	41	21	14	3.91	0.99	1	8	21	37	32	
6	3.63	0.23	0	4	29	55	13	3.67	0.54	1	3	36	50	11	
7	3.58	0.27	0	5	29	63	4	3.56	0.56	1	11	28	50	9	
8	3.74	0.40	0	4	25	63	9	3.78	0.60	1	6	22	57	14	
9	3.16	0.68	2	25	39	29	5	3.28	0.91	5	13	40	34	8	
10	2.95	0.94	4	11	46	27	13	3.07	1.10	3	17	45	31	5	
11	2.42	0.77	29	43	25	4	0	2.31	1.44	24	41	21	7	7	
12	1.47	0.84	68	16	13	4	0	1.65	0.91	57	23	17	3	0	
13	1.42	1.51	57	20	18	5	0	1.75	0.98	58	17	20	4	2	
14	1.74	0.72	75	9	11	4	2	2.07	0.97	38	28	23	8	2	
15	3.63	0.77	4	4	13	55	25	3.76	1.24	7	4	24	38	27	
16	3.26	0.84	11	21	39	20	9	2.98	1.24	4	9	33	41	13	
17	3.26	0.46	4	9	34	48	5	3.35	0.92	4	11	36	46	4	
18	3.26	0.93	2	13	39	39	7	3.30	0.53	3	7	50	37	3	
19	3.58	0.40	0	9	39	45	7	3.41	1.04	2	10	38	44	6	
20	3.26	0.84	13	27	20	36	5	2.98	1.24	9	22	33	32	4	
21	3.53	1.12	5	11	25	48	11	3.43	0.91	2	11	36	43	7	
22	3.68	0.89	2	13	27	45	14	3.70	0.91	2	7	27	49	16	
23	3.68	1.12	5	18	43	27	7	3.45	1.05	6	5	42	35	13	
24	3.53	0.50	4	0	59	30	7	3.63	0.44	1	1	40	50	7	
25	4.00	0.32	0	2	11	48	39	4.07	0.61	0	0	19	54	27	
26	3.26	0.23	0	4	61	27	9	3.39	0.72	2	8	45	38	7	
27	2.53	1.39	32	29	25	13	2	2.71	1.39	17	26	33	18	7	
28	3.58	1.12	2	14	29	32	23	3.55	1.41	4	11	36	25	24	
29	3.47	1.88	4	20	45	30	2	3.61	0.98	0	11	33	40	16	
30	3.68	0.49	0	5	39	55	0	3.69	0.58	2	4	28	56	10	
31	3.47	0.71	5	5	36	46	7	3.45	0.30	1	3	50	44	3	
32	3.16	0.23	2	14	61	23	0	3.27	0.29	1	7	57	33	2	
33	3.37	0.32	0	13	63	23	2	3.27	0.23	0	2	71	27	0	

traditional and blended learning students agreed that they found the course intellectually challenging and stimulating (traditional: M = 3.84, 79% of the respondents agreed or strongly agreed; blended learning: M = 3.79, 71% of the respondents agreed or strongly agreed). They all thought that they had learnt something that they considered valuable (traditional: M = 3.95, 91% of the respondents agreed or strongly agreed; blended learning: M = 4.03, 81% of the respondents agreed or strongly agreed) and that they were more interested in the course as a result of the course (traditional: M = 3.74; blended learning: M = 3.81). They all claimed to have learnt and understood the course material (traditional: M = 3.79; blended learning: M = 3.72). The blended learning students strongly believed that more face-to-face classes would have improved their marks (blended learning: M

Table 3 Table summarising the comparison between learning modalities

	Traditional (N = 56) Mean	Blended learning (N = 107) Mean
Learning	3.78	3.85
Organisation	3.53	3.57
Documentation	3.37	3.35
Evaluation	3.54	3.39

= 3.91, 69% of the respondents agreed or strongly agreed). This shows that students still believe in traditional methods and that they learn more when the lecturer is the interface or conveyor of knowledge than they do when they learn by themselves using IT tools. All the students were generally

satisfied with the course and with what they had learnt (traditional: $M = 3.78$; blended learning: $M = 3.85$). There were no differences with respect to the year in which students graduated.

Organisation

Questions 6 to 9 referred to how well the course was organised. Both traditional and blended learning students found that the objectives proposed agreed with what was actually taught (traditional: $M = 3.63$; blended learning: $M = 3.67$). They thought that the class material was well prepared and carefully explained (traditional: $M = 3.58$; blended learning: $M = 3.56$) and that the instructor's presentations were clear (traditional: $M = 3.74$; blended learning: $M = 3.78$). The way the instructor presented the content made it easy to take notes, according to the students (traditional: $M = 3.16$; blended learning: $M = 3.28$), and they were all satisfied with the way in which the course was organised (traditional: $M = 3.53$; blended learning: $M = 3.57$).

Interaction with the instructor

The instructor's willingness to help and his or her accessibility during office hours and after class was viewed favourably for the two modalities (traditional: $M = 2.95$; blended learning: $M = 3.07$) but almost half of the students neither agreed nor disagreed on the availability of the instructor because they had not tried to contact him or her on any occasion (46% of the students enrolled in the traditional course and 45% of the students enrolled in the blended learning course neither agreed nor disagreed).

Few consultations were had with the instructor during the face-to-face sessions: 72% of the traditional students and 65% of the blended learning students declared that they had had between 0 and 3 consultations in these sessions. This means that, contrary to what was expected, students did not use the face-to-face sessions to solve problems and ask the instructor questions. As stated previously, the purpose of the face-to-face sessions on the blended learning course is basically for the instructor to give guidance to students and interact with them. To our surprise, students on the blended learning course did not make the most of the opportunity to interact with the instructor. The reason for this is likely to be that students still believe that in class they are there to listen and learn from the instructor, rather than to interact with him or her.

Moreover, when blended learning students needed to ask questions they used e-mail and Atenea more than traditional students (75% of the students enrolled in the traditional courses never used e-mail to consult the instructor, while for the blended learning course this percentage was 38%). When students on the traditional course needed to consult the instructor they basically used his or her consultation times. It would seem that they felt more confident when they can

explain a problem in an office, in a small group. Students are not keen on asking questions in class, perhaps because they feel shy or because they feel that their questions may not be of interest to the other students.

Age had an influence on the number of consultations with the instructor. It seems that older students prefer not to query the instructor. Furthermore, students over 30 years old were not keen on using IT tools in any form (e-mail, Atenea, etc.), whether they were on the traditional or the blended learning course (traditional: $M = 1.00$; blended learning: $M = 1.83$). Sixty-one per cent of the students who were over 30 never used e-mail or Atenea to contact the instructor. However, only 47% of the students younger than 30 never used it.

Group interaction

The methods students used to interact with the other members of the group were very revealing. To our surprise, the most used method was face to face: 77% of the traditional students and 65% of the blended learning students mostly or always contacted their partners in person. Blended learning students claimed that they used the time after the face-to-face sessions to arrange the work to be done and to share information on the implementation project that was to be handed in at the end of the course. They believed that it was easier to print their work, show it to the others and explain it in person, rather than using IT. As we expected, the blended learning students used IT to interact with the other students more than the traditional students. The Atenea platform was available only to blended learning students, who used it to obtain information and ask the instructor questions but not to interact with the other members of the group.

The only difference between those students who had completed first cycle degree courses last year and those who completed them a few years before is their use of IT to communicate with the instructor and other students. Even when they were enrolled in the blended learning course they were more reluctant to use these kinds of tools and preferred face-to-face sessions. Fifty-six percent of the students enrolled in the blended learning course who finished first cycle courses last year always or mostly contacted the other students via Atenea or e-mail, while 47% of those students who finished first cycle courses some years ago always or mostly used IT tools for that purpose.

Some of the unexpected results in terms of the lower-than-expected engagement of the blended format students in using the ICT tools could also be attributable to the need to 'train' or 'orient' students (both logistically and psychologically) to new learning modalities. This is commonly experienced in engineering design courses, for example, where students are very frustrated with open-ended problems and self-directed learning, if they have received no prior orientation on how it works, what its goals and strengths are, etc.

Documentation

Questions 17, 18 and 19 were related to the information in the 'Documentation' section. Traditional and blended learning students agreed that the basic material of the course was well prepared (53% of the students enrolled in the traditional course and 50% of the students enrolled in the blended learning course agreed or strongly agreed with this statement) and that the recommended reading list and the complementary material for the course was comprehensive and appropriate (46% of the students enrolled in the traditional course and 40% of the students enrolled in the blended learning course agreed or strongly agreed with this statement). The homework, recommended reading list, basic and complementary material, etc., facilitated comprehension of the course (52% of the students enrolled in the traditional course and 50% of the students enrolled in the blended learning course agreed or strongly agreed with this statement). From these results we can deduce that the material for the blended learning course was well structured. All the students were generally satisfied with the documentation for the course (traditional: $M = 3.37$; blended learning: $M = 3.35$).

Evaluation

Questions 20, 21, 22 and 23 were related to the satisfaction of the students regarding assessment. Face-to-face students found the evaluation methods fairer and more appropriate than did the blended learning students (traditional: $M = 3.26$; blended learning: $M = 2.98$).

From the results, we were able to deduce that face-to-face students interacted with students in the years above them, who were able to offer guidance on the projects and examinations as they knew exactly how the course was assessed from other years. However, the blended learning modality is fairly new and thus the students could not compare the evaluation methods and examinations with students from other years. This introduced an element of uncertainty when students were studying for the examination. It is a fact that, even though students enrol in a university course to learn, they are more concerned with their results than they are with learning.

The face-to-face and blended learning students found that the requirements of the assessments were clear (traditional: $M = 3.53$; blended learning: $M = 3.43$) and that the contents of the examinations and projects corresponded to the content of the course (traditional: $M = 3.68$; blended learning: $M = 3.70$). The contents of the examination were thought to be in accordance with the emphasis given by the instructor to certain aspects of each module (traditional: $M = 3.68$; blended learning: $M = 3.45$).

There were no major differences in the perception of traditional and blended learning students on assessment (traditional: $M = 3.54$; blended learning: $M = 3.39$). However, students who were

over 30 years old found the methods for assessing the work fairer and more appropriate (43% agree or absolutely agree) than did the younger students (35% agree or absolutely agree), regardless of whether they were on the traditional or the blended learning course.

Workload/Difficulty

Question 24, 25, 26, 27 and 28 pertained to the workload and difficulty of the course. Traditional and blended learning students agreed that the difficulty of the course in relation to other courses was moderate to excessive (89% of the students of the traditional students and 80% of the blended learning students found the difficulty medium to hard), that the workload was heavier than in other courses (87% of the traditional students and 81% of the blended learning students found the workload moderate to excessive and that the pace was about right (88% of the traditional students and 83% of the blended learning students found the course pace about right).

Seventy-nine percent of the traditional and blended learning students devoted between 0 and 7 non-contact hours a week to prepare for examinations. The majority of them also spent more than 25 hours in total on preparing their projects.

An incongruity appears in the similarity of the results. From our point of view, blended learning students should have had to devote more time to preparing for the examination than traditional students, but the results show that the amount of time spent was roughly the same.

Other information

The level of interest of traditional and blended learning students in this course before they started the course (traditional: $M = 3.47$; blended learning: $M = 3.61$) (1: very low, 5: very high) and once they had completed it (traditional: $M = 3.68$; blended learning: $M = 3.69$) was similar, although the course increased the interest of both sets of students. Blended learning students thought their marks would be better than the traditional students did, for both the examination and the project.

Students' results

Having analysed students' opinions on the different learning methods in the Industrial Plants course, we provide an assessment of their results. As shown in Table 4, although the marks are quite similar for the two modalities, the success rate is higher for the blended learning modality than for the traditional modality. Similarly, the drop-out rate is lower for the blended learning modality. This may be due to greater motivation in the blended learning students and their use of Atenea, which improves access to the contents and communication with the instructor and other students.

Table 4. Comparison of students' results

	Traditional (N = 56)		Blended learning (N = 107)	
	2004–2005	2005–2006	2004–2005	2005–2006
Drop-out rate	10%	14%	2%	12%
Students with a mark lower than 5	23%	25%	21%	19%
Students with a mark between 5 and 7	54%	42%	58%	54%
Students with a mark higher than 7	13%	19%	19%	15%

CONCLUSIONS

The effective integration of face-to-face sessions and Internet technology is the basis of a successful blended learning course, as can be deduced from the perception of the students and their use of the Atenea platform. Moreover, the most significant difference between traditional and blended learning modalities is the synchronous and asynchronous interaction between students and with the lecturer/instructor, using ICT tools to facilitate collaborative learning experiences.

This study, which compares the relative effectiveness of a traditional approach to education and the relatively new blended learning modality, leads us to conclude that students' perception is quite similar with regard to the two modalities. Although students had different profiles (professional situation, age, dedication, etc.), the results were generally the same. Both types of students were satisfied with the course, including its organisation, documentation and assessment, and with their own progress. However, some students still did not know what blended learning meant exactly and still thought of classes in a traditional manner. It will be a matter of time and of adapting to these

new learning methods before students realise the benefits of such a modality. There were also differences with regard to the use of ICTs between students and between students and the instructor. As expected, blended learning students used ICTs more than traditional students.

With reference to the evaluation methods, although traditional students found them fairer and more appropriate than blended learning students did, blended learning students had better marks and dropped out less than traditional students did. Therefore, we are able to conclude from this study that blended learning students progressed in accordance with initial expectations. Academics at UPC seem to have adapted their teaching methods to IT tools.

In conclusion, the results of this survey show that the learning objectives were attained in both the traditional and the blended learning modality and that students' perception and results were quite similar. Therefore, we feel that, although the blended learning modality is relatively new to UPC, the students' favourable assessment of it means that it could be implemented effectively in other courses or university degrees in engineering, aeronautics and even other fields.

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APPENDIX 1

Questionnaire

Format	Year	Situation	Gender	Age			
<input type="checkbox"/> Degree in Industrial Engineering and Scheduling—Traditional	<input type="checkbox"/> Autumn 2004	<input type="checkbox"/> Student	<input type="checkbox"/> Male				
<input type="checkbox"/> Degree in Industrial Engineering and Scheduling—Blended learning	<input type="checkbox"/> Spring 2003	<input type="checkbox"/> Student who is employed	<input type="checkbox"/> Female				
		<input type="checkbox"/> Employee who is studying					
When did you finish your undergraduate degree?							
			Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
<i>Learning</i>							
1. You found the course intellectually challenging and stimulating.			1	2	3	4	5
2. You have learnt something that you considered valuable.			1	2	3	4	5
3. Your interest in the course has increased as a result of this course.			1	2	3	4	5
4. You have learnt and understood the material for this course.			1	2	3	4	5
5. Your mark would have improved with more face-to-face classes.			1	2	3	4	5

<i>Organisation/Clarity</i>										
6. The proposed objectives agreed with those actually taught, so you knew where the course was heading.						1	2	3	4	5
7. The class material was well prepared and carefully explained.						1	2	3	4	5
8. The instructor's presentations were clear.						1	2	3	4	5
9. The instructor gave presentations in a way that made taking notes easy.						1	2	3	4	5
<i>Interaction with the instructor</i>										
10. The instructor was generally accessible to students during office hours or after class.						1	2	3	4	5
11. How many consultations did you make to the instructor during the face-to-face sessions?						1	2	3	4	5
1. None	2. Between 1 and 3	3. Between 3 and 5	4. Between 5 and 7	5. More than 7						
12. How many consultations did you make to the instructor outside the face-to-face sessions?						1	2	3	4	5
1. None	2. Between 1 and 3	3. Between 3 and 5	4. Between 5 and 7	5. More than 7						
13. How often did you consult with the instructor face to face?						1	2	3	4	5
1. Never	2. Seldom	3. Sometimes	4. Often	5. Always						
14. How often did you use Atenea, e-mail, etc. to consult with the instructor?						1	2	3	4	5
1. Never	2. Seldom	3. Sometimes	4. Often	5. Always						
<i>Interaction with the group</i>										
15. When working in a group, how often did you meet other members of the group face to face?						1	2	3	4	5
1. Never	2. Seldom	3. Sometimes	4. Often	5. Always						
16. When working in a group, how often did you contact the other members of the group via Atenea or e-mail?						1	2	3	4	5
1. Never	2. Seldom	3. Sometimes	4. Often	5. Always						
<i>Documentation</i>										
17. The basic material of the course was well prepared.						1	2	3	4	5
18. The recommended reading list and complementary material for the course was comprehensive and appropriate.						1	2	3	4	5
19. The homework, recommended reading list, basic and complementary material, etc., facilitated comprehension of the course.						1	2	3	4	5
<i>Evaluation</i>										
20. The methods of assessing students' work were fair and appropriate.						1	2	3	4	5
21. In general, the requirements of the assessments were clear.						1	2	3	4	5
22. The examination and project contents corresponded to the course content.						1	2	3	4	5
23. The examination contents were in accordance with the emphasis given by the instructor to certain aspects of each module.						1	2	3	4	5
<i>Workload/Difficulty</i>										
24. In relation to other courses, the course was:						1	2	3	4	5
1. Very easy	2. Easy	3. Medium	4. Hard	5. Very hard						

25. In relation to other courses, the workload was:					1	2	3	4	5
1. Very light	2. Light	3. Medium	4. Heavy	5. Very heavy					
26. The pace was:					1	2	3	4	5
1. Too slow	2. Slow	3. About right	4. Fast	5. Too fast					
27. On average, how many hours a week did you need to prepare for the examination?					1	2	3	4	5
1. Between 0 and 2	2. Between 2 and 5	3. Between 5 and 7	4. Between 8 and 12	5. More than 12					
28. How many hours did it take you to prepare the project, outside class-time?					1	2	3	4	5
1. Less than 10	2. Between 10 and 25	3. Between 25 and 35	4. Between 35 and 50	5. More than 50					
<i>Other information</i>									
29. Your level of interest in the course before you started the course was:					1	2	3	4	5
1. Very low	2. Low	3. Average	4. High	5. Very high					
30. Your level of interest in the course after finishing the course was:					1	2	3	4	5
1. Very low	2. Low	3. Average	4. High	5. Very high					
31. The final mark you expect for the project is:					1	2	3	4	5
1. Less than 3	2. Between 3 and 5	3. Between 5 and 7	4. Between 7 and 9	5. More than 9					
32. The final mark you expect for the examination is:					1	2	3	4	5
1. Less than 3	2. Between 3 and 5	3. Between 5 and 7	4. Between 7 and 9	5. More than 9					
33. The average mark you expect for the Degree is:					1	2	3	4	5
1. Less than 3	2. Between 3 and 5	3. Between 5 and 7	4. Between 7 and 9	5. More than 9					