Blended Learning in University Education: Activities, Results and Quality

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1. Introduction

Nowadays University education is faced with new challenges necessary for a successful convergence with the European Higher Education Area (EHEA). At the same time, the advance of the information and communication technologies (ICT) has been very rapid during the last years, especially in all aspects related to internet. In the near future, education in all its levels will have to incorporate, to a greater or lesser extend, interactive webs as teaching tools. In this sense, web platforms turn into virtual classrooms with the aim of making easy and improving the learning processes.
Technical or scientific education has not kept out of this situation, and numerous pilot courses have tackled the question of improving the teaching by interactive webs. This type of resource promotes the autonomous learning, aspect so necessary in future engineers or scientist, and increases the student's motivation. Besides, learners use their time more efficiently. At the university level, the goal of the teaching-learning process is not simply to accumulate knowledge, but also to provide tools to learn how to learn.
During the last three academic years, two Physics subjects (Physics I and Physics II) belonging to the first year of an engineering school were taught by using a blended-learning (b-learning) method. Part of the activities developed in classroom was replaced by learning and training activities through an interactive web: the program Moodle. This work reflects the main conclusions of this experience. Fist of all, different considerations about the use of the projector, one of the main resources of this method, are exposed. Below, a new methodological prospect of teaching based on student's work in class is analyzed. This technique is especially useful for small groups of students. The central part of this work is focused on the exposition of the b-learning pedagogical method, and especially, of the web activities. Finally, quality and efficiency of this methodology and its activities are discussed. The number of passed students by the b-learning and traditional models are compared, and the students' satisfaction is assessed and analyzed by a survey.

2. The Projector

The use of the audiovisual aids in teaching is unstoppable and progressive, especially, due to the continuous development of the ICT. Videos and computer presentations are examples of these novel variants introduced in the field of teaching. However, in the transmission of the scientific knowledge, the implementation of these avant-garde resources requires the knowledge of their advantages and drawbacks. Educational institutions have committed themselves to modernizing the didactic resources; since conscious of the power of the new communication tools when it comes to triggering attention, perception and intelligence mechanisms, they do not want to waste the opportunity to improve the education system. Teacher should also transfer the technological advances of the present society to the field of knowledge, and avoid, in this way, a technical imbalance between learning methods and real life. The aim of the projection techniques is to improve the learning efficiency, that is, the optimization of the time devoted to the study by the student.

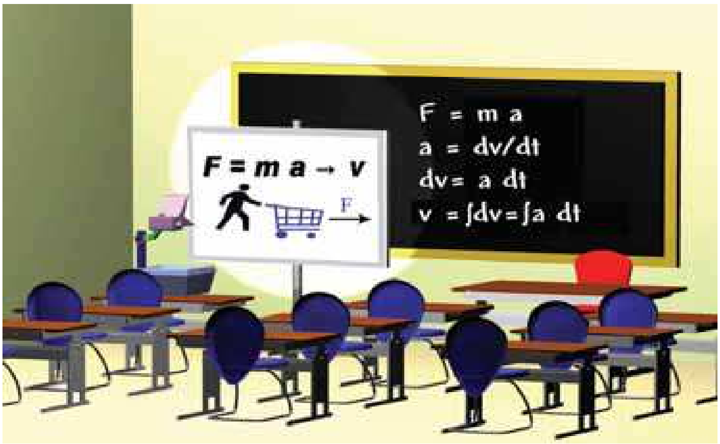

Fig. 1. Main uses of the projector in the lecture room: drawings and diagrams; and of the blackboard: mathematical developments.

2.1 Characteristics of the Implemented Contents

The way of synthesizing contents in audiovisual resources is a key aspect of the teaching process. The basic principles of content implementation are: legibility, clarity, simplicity and sharpness. This resources must transmit, especially, graphs, drawings and diagrams as shown in Fig. 1. All these elements are difficult to make during the teacher’s explanation.

It is important the sequentiality of the exposition. Contents should appear progressively by using data-hiding techniques. Mathematical developments must be omitted as far as possible. Contents should be completely structured, and exposition should focus on the main aspects of the subject. The speed of the explanation is other important element. Teacher should follow a comfortable rhythm for student, so that this can copy the information necessary to understand the content. Below, a series of conclusions related to the use of audiovisual resources in class are summarized.

2.2 Improving the Use of Audiovisual Means

The first aspect influenced by the use of the projector is the behavior of the student in class. From the teacher's point of view, it is better that student devotes his time to understand than to copy information. The projector favors this fact unlike the blackboard. However, if the lack of study prevents the understanding, the class turns into a temporal vacuum that student can fill by speaking to his classmate. The use of the projector, in these situations before discouraged audiences, forces teacher to make summaries, to show contents in an even more organized way, and in the case of the problem solving, to review the theoretic aspects. Besides, if the preparation is not meticulous, the combined use of the projector and the blackboard may cause distraction for the students.

Different surveys among students show that these recognize the positive aspects of the audiovisual resources: better previous preparation of the subject, better graphs, and greater dynamism of the exposition; and that they value them favorably. However, they considers than the content of this resource is not always sufficient. Presentations can not accommodate all the information of a topic because this would be against the basic principles of this resource. Therefore, additional information always has to be supplied to the student.

The use of the projector is not only limited to the 'master class', since they can direct the student's work in class during the problem solving. In this case, student must work actively by completing and solving strategically chosen parts of the problems. Presentations must show solved problems in an incomplete way by making use of information-processing techniques (Fuller, 1982; Jiménez-Sáez et al., 1996). Previously, student must have always received a suitable training in solving easier problems. Teacher must encourage students to research into problem solution methods, since then they will manage to have a good grasp of the theory. However, teacher fights against the student's inertia to work and the time available to do this in class. Let us not forget the maxim affirming that one learns something faster when one does something.

The student's insecurity to accomplish certain mathematical developments is a drawback for the use of the projector. This fact incapacitates the student to assimilate condensed information by concepts and outlined by processes in a presentation. Student prefers detailed developments. However, teacher has a limited time in all topics, and this must conjugate the information supplied by presentations and by other means (documents, books, etc.).

From the teacher's point of view, the fact of having more time available to transmit ideas by using audiovisual resources can redound to better explanation. However, sometimes and especially when the student begins the learning of a subject, it is necessary to show in details all steps of the resolution of a problem or of the demonstration of a theorem. The difficulties found for a student in a presentation do not totally coincide with those that the teacher can predict. The feedback of the combined use of projector and blackboard gives this method a greater potentiality against the individual use of the two resources.

Nowadays, computer programs are still rather limited and little flexible when it comes to implementing scientific concepts in computer notes. It is necessary a deeper investigation in this field to develop user-friendly programs to introduce graphs, drawings and mathematical formulas.

2.3 Conclusions

It is clear that several difficulties arise, when audiovisual teaching resources are used. Teacher and student should joint their efforts to benefit from the advantages of these means. To stimulate the communication and interactivity between teacher and student is not only an obligation, but a way to follow. Abilities of constant adaptation and evolution are necessary in both, but especially the interiorization of suitable habits. Thus, the student will be able to make better use of the opportunities offered by a coexistence of old (blackboard) and new (computer-assisted projection) teaching technologies; and the teacher will be able to adapt its didactic methodology to the needs of the student and the contents.

3. Didactic Methodologies based on the Student's Work

Didactics methodology is the key to the teacher's performance. A suitable methodology is fundamental to direct the student's learning. In this study, the teacher's performance in class is improved in the field of didactics of experimental sciences, such as, Physics or Chemistry. A new methodological prospect of teaching based on student's work is analysed. The student's opinion has been assessed by taking a survey. Its results are discussed, since they reveal the possible difficulties of the method, as well as, its advantages. Subjects or topics with a small number of students and involved didactic objectives are the better candidates for the substitution of methodologies based on the 'master class' for others characterized by the direct transmission of knowledge from teacher to student in class.

3.1 The Teaching Method

University studies to date have been structured mainly round the 'master classes'. The main reason is the high number of students. For long time, the generalized use of this formative strategy has consigned others to oblivion, even if the results of these latter were better. Undoubtedly, a teaching methodology based on the student's work in class can transmit a smaller number of knowledge. However, this fact does not dismiss the application of this methodology in subjects with a great number of didactic objectives; but in this case, its implementation should be limited to the achievement of the main objectives. Thus, the student can acquire these knowledge or abilities in class by following this methodology, whereas the rest of secondary objectives will be reached by the application of other methods. In fact, the adaptation of the university teaching to the European credit system (ECS) is based on the use of the student's work as the centre of the training process (Gonzalez & Wagenaar, 2003).
This type of methodology was applied in certain problem classes of the b-learning courses of Physics, and in addition, in all classes of the subject of Experimental Techniques in Physics and Chemistry belonging to the first year of the Aeronautical Engineering degree. In this subject, a deeper study of this methodology was accomplished by consulting the students' opinion. This subject considers the acquisition of a small number of objectives. The development of a class is the following: For about 30 minutes, teacher explains a series of theoretical and practical contents by using resources, such as, the projector. For the remaining 60 minutes, student must accomplish a set of exercises based on the previously exposed topic, working in group or individually. The problems must be divided in little parts (Wickelgreen, 1974), being interesting that one or several students at the same time,

together or independently, solve each one of these parts in front of the rest on the blackboard with the help of the teacher. This way of acting is reflected in Fig. 2.
From the cognitive point of view, researchers suggest that the conceptual and progressive change of the thought is the result of the mental processes involved in the solving of conflicts and contradictions. Thus, the confusion and the conflict between the new acquired knowledge and the knowledge that the learner already had during a discussion in class had a considerable potential to increase the learning of the student when this process is guided suitably by the teacher (Cobb et al., 1992).

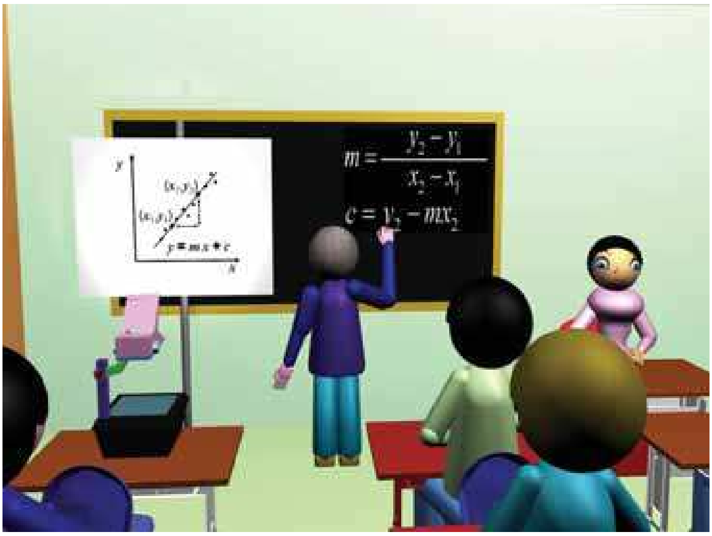

Fig. 2. The didactic method revolves around the student's work.

3.2 Improving the Method from a Survey

Below, the results of a survey among students on this way of teaching are discussed. The number of students in the subject of Experimental Techniques was about 390 divided in groups of 30 students. Students should compare the traditional methodology with this methodology in different aspects. They should declare its agreement with several affirmations in a scale of three levels: H-high, M-middle, L-Low. Results are shown in Fig. 3.
The teacher's way of explaining:
1.1. The initial theoretical explanation is short but enough to follow the class.
1.2. The use of audiovisual means facilitates the understanding of the theory.
1.3. Teacher accomplishes enough examples to solve the exercises.
1.4. I do not need the stimulus of the teacher to work in class.
The work in class:
2.1. I had the basic knowledge necessary to understand the subject.
2.2. I need more time to assimilate contents necessary to solve the class exercises.
2.3. I try to solve all exercises and do not copy the solution.
2.4. I am capable of solving the larger part of the exercises.
2.5. I solve the exercises, but I do not understand the theoretical basis.

2.6. I collaborate actively with my classmates to solve the exercises.
2.7. I do not like solving exercises in front of my classmates on the blackboard.
2.8. I do not ask teacher my doubts.
2.9. The learning attained in class is high.
Overall assessment:
3.1. I think this methodology is suitable.
It is remarkable how the students develop their learning ability and manage to assimilate great part of the didactic objectives in the brief teacher's exposition (question 1.1). Besides, they positively assess the use of innovative didactic resources, such as, the video projector (q.1.2). However, this teaching method always has, as limitation, the time to transmit information from teacher to student. The student and its peculiarities should not be forgotten either, since each one of them has a different learning ability, and the teacher can not follow a uniform teaching-learning rhythm without taking into this fact. Thus, around 10% of students (q.1.3) declare losing the conducting thread of class. Teacher, besides transmitter, should be motivator. Even, this latter, the facet of stimulator teacher, is maybe more important than the former, the facet of connoisseur teacher. At any time, teacher must know how to encourage and guide the student's work: he must know when students must work in group or individually, when some students must solve a part of the exercise on the blackboard, or when he, in person, must solve this part, always avoiding that the student limits himself to copy results. The student needs to practice what he is learning and to make tasks showing its ability (Stigler & Hiebert, 1997).

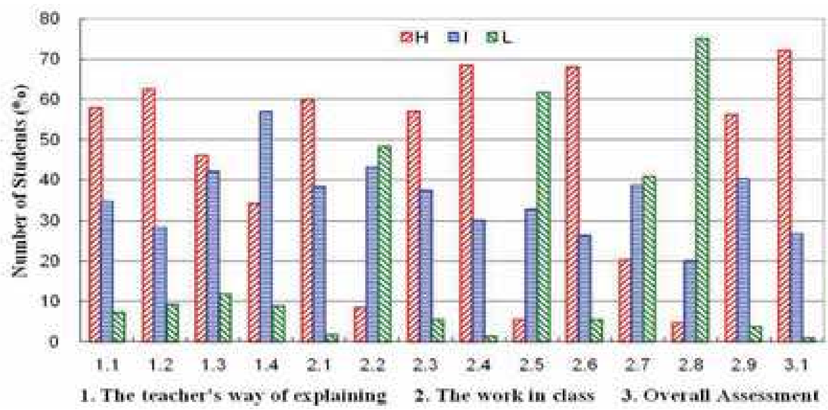

Fig. 3. Results of a survey among students comparing a methodology based of the student's work in class with the 'master class'.

Questions from section 2 are the most revealing, since they indicate both advantages and troubles of application of the method. Question 2.1 shows that around 3% of students lack basic knowledge to face the course. At the beginning of the course, a revision course ('zero course') of two or three weeks devoted to the review of the knowledge and skills of previous formative stages stars to become widespread in scientific and technical degrees in order to attenuate this problem. Even, this number of students could be considered larger taking into account the following question: Around 50% of students do not understand the theoretical contents in a reasonable time (q.2.2), which forces a lot of them to copy the resolution of the exercises from their classmates (q.2.3). A number larger than 5% declares (q.2.6) inconvenience of working in group. This set of students slow down the advance of the whole during the class, since the achievement of a student working alone is smaller than working in group, given that the latter can compare and contrast procedures and solutions. Also, an important number of students (about 20%) reflect their opposition to show their abilities in front of the rest of classmates on the blackboard (q.2.7). This procedure leads to acquire skills, such as, a good oral expression in public and a good organization of ideas faced with questions of classmates. The main reason is again their bad basic knowledge, and hence, the fear of showing this lack in front of their classmates. Therefore, according question 2.7 the number of students with a low level of knowledge reaches 20%. In addition, some of these students do not solve their doubts (q.2.8).

An important achievement of this methodology is the high degree of learning in class (q.2.9). However, it is necessary to include this plan of action in a continuous-assessment process in order to encourage the study, and thus to consolidate knowledge. Finally, the more outstanding aspect of this survey is the final question (q.3.1). Up to 72% of students positively assessed this teaching method. This fact together with the improvements in the academic results turn this methodology into an indispensable option for teacher.

3.3 Conclusions

Didactic methodologies based on the student's work are currently a teaching procedure little used at the university. However, from of student's point of view is a highly satisfactory method, both in training and in efficiency, as shown a survey taken among students. In fact, current trends toward the adaptation to the ECS base the teaching on the workload developed by the student. Nevertheless, there are still a lot of obstacles left in order to implement this type of methods. This strategy means, at least, to double, or even, to triple, the teaching means: lecture rooms, video projectors, etc. As well, it means to increase, to the same extent, teacher's teaching efforts, each day less assessed by the political class to the detriment of other daily tasks, such as, the research activity. Therefore, several questions arise when it comes to improving the quality of university teaching: Can university increase the means to tackle the implementation of this methodology? Is it possible to decrease the ratio of students to teacher? Besides these uncertainties, there are other problems related to the student: Can the training program contain less didactic objectives to decrease the student's workload? Can student bear a process of continuous work? In short, rather dilemmas still need to be solved in order to successfully implement this strategy.

4. Design of a b-Learning Teaching Unit

The Bologna Declaration signed in 1999 by the Ministers of Education of 29 European Countries set the creation of the EHEA. This new framework revolves around a new way of measuring the learning, namely, the European Credit Transfer System (ECTS), based on a new university credit. This credit, recognized in every country, is based on the student's work time in each subject and not on the teacher's teaching time, and should reflect every aspect of the educational life: time devoted to the on-site education, to the problem solving, to the laboratory work and to the personal study, among others.

The aim of adaptation to the EHEA is producing vertiginous changes in the university life (De Miguel, 2006; Ramírez et al., 2007). At present, one of the main social functions entrusted to the University is to teach students how to learn by themselves; so these students will be turned into autonomous professionals in the exercise of their profession in an immediate future. Therefore, the learner has become the centre of the university life. Once the competencies of the subject are established, the main element of change is a detailed planning of the teaching process based on the spirit of the new credit. This planning must specify sequentially all the whole activities to carry out by the student in the learning process to achieve these competencies. Besides, it is necessary to structure the university teaching about systems that reflect and bring these concepts closer to the student. In this sense, the virtual classroom bursts into the student life and turns into a teacher's basic tool.

Nowadays, the interactive webs have reached a great peak (Ramírez et al., 2007). These webs show the set of activities to develop by the student interacting with the system. Hence, the own webs take part in the teaching process becoming an educational resource. Computer programs, such as, Moodle, WebCT (Blackboard), Claroline, Dokeos, or ILIAS, incorporate from day to day new performance capabilities, so that the teacher has new pedagogical instruments for teaching. However, at the present time the degree of integration of the interactive webs in the university teaching is still scarce due to problems of lack of standards and to the difficulty to turn information and methodology into computer material.

Below, a practical case of structuring the university teaching in an engineering subject around an interactive web is shown. Our attention is focused on the generic plan of action of the teacher directed to the achievement of a series of specific competencies of scientific and technical nature by the student. This performance considers the elaboration of activities in each of the different topics of the subject in an interactive web. In our case, the program Moodle, one of the most accessible tools since it is distributed under general public license (GPL) created by the 'Free Software Foundation', was used.

4.1 Learning Virtual Environments

Blended learning is learning supported in the ICT and focused on the student's interactive learning (Fig.4). Traditionally, the Learning Virtual Environments (LVE) have been a solution to time- and geographic-separation problems of the learner (García Aretio, 2001). For example, this type of teaching is especially useful for the permanent training of people with a job. However, nowadays these virtual classrooms have been turned into a new tool usable for the university teaching in his attempt to adapt to the EHEA, since they concentrate their efforts on the learner and his work to have a good grasp of the subject.

Multimedia materials force the teacher to condense the key information for the student. Questionnaires complement this formative task, since they accomplish a double mission: they allow the student's self-assessment and they are suitable for knowing if this understands the subject matter. Very selected proposed and solved problems extend the knowledge of the learner since they apply the theory. Although the teaching time decreases, the control work of the flux of knowledge toward the student increases. The less interactivity between teacher and learner; and therefore, the less feedback in the learning must be compensated with a greater tutorial action. This action will support the learning process and help the acquisition of new learning strategies by the student.

The production of b-learning contents is one of the key tasks of the education with interactive webs. Nowadays, teachers have to spend a great amount of time and effort to produce this type of educational material. Besides, there are other two additional problems:

the 'reusability' and 'interoperatibility' of the created material, that is, teacher finds the drawback of not been able to use the same contents in different educational programs, either due to the compatibility problems or because they are patented. These disadvantages have slowed down notably the spreading in the university of the web-based learning models. At present, the main use of the interactive webs in engineering education is the content-based learning, relegating the constructivist learning and the collaborative learning to certain hardly used educational modules (Weller, 2002; Dillenbourg, 1999). Content-based learning is based on supplying the more appropriated contents to the student in each moment, including the completion of questionnaires. This type of learning imitates teaching techniques such as the 'master class' or the problem solving. The creation of generic modules which mean new pedagogical approaches to the constructivism and collaborative principles through the emulation of teaching methods, such as, the cooperative learning, problem-based learning, project-based learning, or the case study is still incipient and difficult to accomplish.

Fig. 4. Picture of a lecture room in which teacher uses the ICT as resource.

4.2 Teacher's Tasks

Teachers of an educational institution must organize the teaching process in each of the subjects. Their first action should be directed to formulate the specific and transversal competencies reached by the student after the learning process. The achievement of these competencies means the development of a work by the learner, either of personal study or of carrying out of tasks. Both must be included by the teacher in the 'education guide'. This guide should reflect the set of sequential actions in a LVE. However, unlike a written book, a LVE allows that these actions find a channel or means to be accomplished by using its different modules. In the case of Moodle, theoretical and practical contents can be exposed in text documents, web pages, or through multimedia files by using links to files; problems to solve can be posed, submitted and assessed (even there is a option to grade problems delivered by hand); information and news can be exchanged by using the forum or the messaging service between two people; and multiple choice or true and false questionnaires among others are useful to the student, which can learn and self-assess, and to the teacher, which can assess the student. Besides, there are other resources, such as, a notice calendar and a grade page of the student and that the teacher can manipulate, even download in spreadsheet format. Great importance in the engineering and scientific education has the latex filter that allows to implement mathematical formulas and equations.

The teacher should organize an set of activities in a LVE so that the student follows the development of the subject and achieves an autonomous and significant learning. The virtual pedagogic modules try to get the learner by himself to acquire new learning strategies, that is, they try to get this to turn into a strategy apprentice (Ramírez et al., 2005).

Other labor of the teacher is to provide feedback to the learning process. This labor is only achieved partially through asynchronous communication tools, such as, the forum. This task together with the labor of motivation and advice complement each other. The organizational modality to develop all of them is the tutorial class. This class is focused on the learning personalization and plays a fundamental role in the b-learning method, since the number of on-site hours decreases. The job of the teacher also includes the learner's assessment task. The teacher should create self-assessment activities for the student and later must grade the knowledge acquired by this by using appropriately designed quizzes. Besides, the teacher should also assess other tasks commended to the student and show him the results so that this is aware of his progresses.

4.3 Design of Activities in a Chapter

Below, the composition of a teaching unit used in this pilot scheme in Moodle is shown (Fig.5). The order of execution of activities coincides approximately with the order in which appear in the text. Broadly speaking, this would be also the structure of a b-learning teaching unit for any subject of technical or scientific nature. A basic teaching unit consists of the following modules:

Documents with clear and detailed developments of theory including applications and proofs. Student can use them as learning complement: solving doubts and widening knowledge.

Presentations of transparencies used in live classes for explaining theory. All concepts that the teacher considers essential for the student to acquire the necessary knowledge in the corresponding subject are included in this type of means.

Learning questionnaires with multiple choice questions. Every questionnaire is generated randomly from a database of a large number of queries. Both the order of the questions and the order of the answers in every question are random. Once solved, student immediately receives the corrected questionnaire, that is, besides his mark he can observe the right answers. Student can complete all the questionnaires he wants. This type of questionnaire is designed for learning; therefore, it can be carried out from any IP address, and therefore, the student can use any type of help. These multiple-choice tests allow student to fix and incorporate the most important theoretical concepts in his tree of knowledge. It is especially important the fact that several possibilities are offered student about a concept and that this have to choose the correct. True and false questions lack this formative component.

Self-assessment questionnaires with false and true questions classified by the level of difficulty in several groups (of the order of three: easy, intermediate, and difficult). Every questionnaire is generated randomly from a database of a large number of queries. Once completed, student receives both his grade and the right answers. Besides, this can accomplish all the questionnaires he wants. This type of questionnaire can be carried out from any IP address. The teacher should raise students' awareness of the importance of the accomplishment of these questionnaires individually and without notes. Doubts and lack of knowledge must be resolved a posteriori once finished the test. Therefore, the efficiency of these quizzes will depend to a great extent on the student's responsibility. In short, it is fundamental that this understands the meaning of the feedback in the learning process.

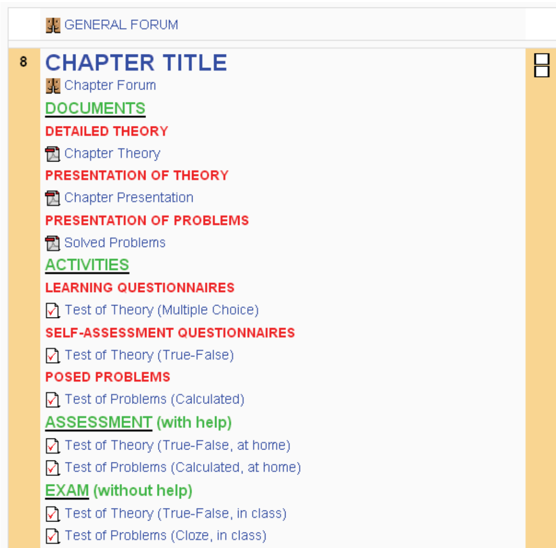

Fig. 5. Example of activities of a b-learning teaching unit in the program Moodle.

Documents and presentations with solved problems by the teacher in live classes for reference and revision. The teacher must select a series of key exercises illustrating the application to practical cases of the theory. In subjects of technical and scientific nature, the use of the didactic technique of problem solving is a fundamental tool for the intellectual development of the learner. This part of the subject is the more difficult for the student, little used to thinking and reasoning out.

Questionnaires of problems with calculated questions generated randomly from a database of a large number of problems classified by the level of difficulty in several groups. These problems must revolve around the fundamental aspects of each topic of the subject. Their mathematical complexity should not be great. Calculated questions allow teacher to offer different students a same problem with different input numerical data, and therefore, with different numerical solution. This reduces the possibility of copying solutions among students. Again, the feedback process is a fundamental tool in the learning since the student to solve other problems must be based on previously solved problems, i.e., on his experience.

Control activities are also important in a teaching unit. At the end of each topic, these activities should appear in order to put the learning-feedback process into practice. Therefore, they are obligatory activities. The grades in these activities must have a weight in the final note of the student, besides the final exam and other class activities (as long as the number of students allows their accomplishment). Questions of these quizzes must be extracted from the previously used databases. Assessment tests are useful to encourage the student's personal work. The student must accomplish two types of assessed activities:

Questionnaires of theory: student has to answer one or several true and false questionnaires with a time limit at home. Hence, the student can use his notes. Once completed, the student receives the mark and the right answers.

Questionnaires of problems: the student has to solve several calculated questions of different difficulty with help of his notes at home. In general, the student has several attempts to solve the same problems.

To complete the control process student must demonstrate the acquired knowledge. Hence, he must carry out two activities under direct supervision of the teacher, which must check that these are accomplished individually:

A questionnaire of theory with true and false questions of different difficulty. Teacher must restrict the range of IP addresses with access to this quiz, since it must be accomplished from the school computer classroom. The student immediately receives his grade.

A questionnaire with a problem of similar difficulty to the previously solved ones. This problem would be a cloze question; since, unlike calculated or numerical questions in Moodle, this type of questions allows several alphanumeric or numeric answers (with different weight in the final grade of the question) under the same wording. This allows to mark several items in long problems, and to avoid binary marks little representative of the student's knowledge.

In addition to the previous activities, other two modules in Moodle are fundamental to develop this education project: the forum and the messaging service. The former allows students to clarify and make progress in their knowledge by using techniques of cooperative learning; and the latter allows to solve individual doubts by a communication between teacher and student or between student and student. In order to develop a suitable feedback task, there are two forums, one devoted to topics related with the chapter and other devoted to more general questions.

4.4 Conclusions

The design of basic teaching units in b-learning for scientific and technical subjects should consider both theoretical and applied activities. The lecture of a good reference manual, the study of more brief and condensed expositions and the accomplishment of quizzes can be mentioned as theoretical activities. As applied activities, the students should attend problem-solving classes to learn solving methods of model exercises; and besides, they have to solve other posed problems to practice. These activities are complemented with others of assessment and verification of the learning. The theoretical knowledge will be assessed by using quizzes carried out by the student with and without help. The practical knowledge will be verified by grading several proposed problems and solved with all type of help, and some suitably designed problem and solved without help. With this type of methodology, the teacher's tasks are similar as with the traditional teaching, with the difference that the control activities become more outstanding than the expositive ones. Besides, the condensation capacity of the teacher should be greater and also this should be more qualified from the point of view of the manipulation of computer resources.

5. Absolute Results of a b-Learning Methodology

This project of educational innovation began three years ago with the installation of the free software Moodle. From this date, the capabilities of this program have increased, and successive updates have been necessary to make good use of all its potentiality. Besides this program, two additional tools must be installed for the appropriate functioning of Moodle: A server program such as Apache (also free) controlling the access to an internet domain and a free database-management program such as MySQL. Once installed, two databases should be entered in Moodle, one of them specifies those students with access to the system, and other indicates the subjects in which these students are enrolled.

Two subjects, Physics I and Physics II, belonging to the first year of the Aeronautical Engineering degree were taught by using a b-learning methodology (Jiménez-Sáez & Ramírez, 2008). These subjects were only addressed to repeat students. Below, the temporal evolution of a virtual teaching unit implemented in Moodle is described. Besides, the efficiency of this teaching method is analysed by comparing the number of passed students in these courses with the number of passed students in previous courses taught by a traditional methodology.

5.1 Evolution of the Learning Activities

First at all, multimedia presentations with theory summaries were carried out. Given the applied nature of the subjects, it was also necessary to develop presentations of solved problems. In a second stage, databases of theoretical questions of the true and false and multiple-choice types were created. Unlike other programs, Moodle allows to introduce figures and mathematical equations (in latex language) in these questions. Several easy-use equation editors, such as Mathtype, translate any equation into this language. The last stage of the project, and maybe, the more important for this type of subjects, was the implementation of databases of applied questions, that is, problems. Moodle has the so-called 'calculated questions' in which the input data are numbers generated randomly by the program. In this way, the possibility of solving problems by copying the solution from a classmate is reduced notably. This resource is especially useful in large groups of enrolled students as happens in the first year. Both the theoretical and applied questions must be classified by the level of difficulty in different categories. Thus, the student can solve quizzes of different level and know his progresses at any time.

5.2 Absolute Results of a b-Learning Methodology

The following samples of students have been considered in this study:

Repeat students (sample R1 with 218 students in Physics I and 143 in Physics II)≡(sample R1, 218, 143) and first-enrolment students (sample E1, 147, 212) following both a traditional methodology during the year 2005-06. Classes were taught by the 'master-class' method. The students must pass an only exam and the final grade was obtained from this.

Repeat students following a b-learning methodology (sample Rb2, 73, 74) and a traditional methodology (sample R2, 139, 135), and first-enrolment students following a traditional methodology (sample E2, 128, 117) during the year 2006-07. Sample Rb2 were formed by students who only have to resit two o less subjects of a total of 5 per four-month period (Physics I and Physics II last a four-month period). Hence, this group of students was the more outstanding among the repeat students.

Repeat students following a b-learning methodology (sample Rb3, 236, 162) and a traditional methodology (sample R3, 34, 112), and first-enrolment students following a traditional methodology (sample E3, 230, 260) during the year 2007-08.
Fig. 6 shows the ratio of passed students to students sat the exam. This graph shows the goodness of the b-learning methodology, since the number of passed students is considerably larger in samples Rb1 and Rb2 than in samples R or E. The students had the chance of passing the subject in two examination sessions. Previous results correspond to the first session. For the second session, results (not shown here) are only slightly better in the b-learning method in general. The main reason is that b-learning students of the second session wasted the activities of the course. They obtained regular or bad grades in these tasks. Besides, given that they had finished them, at least, three months before the date of this 2nd exam, the memory of the acquired knowledge by means of these activities was scarce in this exam. In short, the preparation for this second exam of b-learning students and of the rest of students was rather similar, since both groups used the same resources: only notes and no activity.

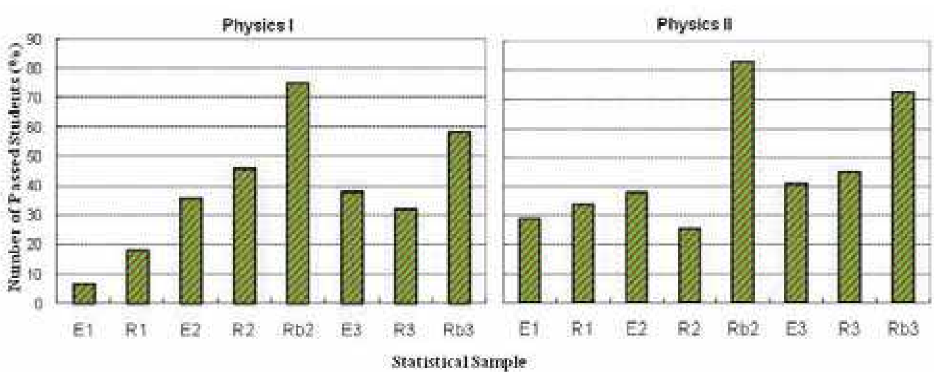

Fig. 6. Ratio of passed students to students present at the exam in Physics I and Physic II for the different statistical samples.

Other notable characteristic is that the results for the sample Rb2 are better than for the sample Rb3. This fact is the consequence of the selection of better students for the sample Rb2. Let us remind that these students had passed more subjects of first year than the students of the sample Rb3. Physics I and Physics II were taught by different teachers, therefore the following two characteristics: subject and teacher have not been determinant at all, except for a deviation around 10% in the number of passed students in Rb2 and Rb3.
The characteristics of the members of the samples E and R are different. Undoubtedly, a statistical study with first-enrolment students following a b-learning methodology would be necessary for future investigations. Although, the results for the samples E and R are similar, differences are important when the ratio of passed students is made with the number of enrolment students (not present at the exam). Thus, the percentage of passed students for the samples E would be smaller. Let us remind that the number of first-enrolment students giving up these subjects in their first year is important. The reason is that between repeat and first-enrolment students there is a great difference in motivation and knowledge at the beginning of the course.

Repeat students of the samples R and Rb took the same exam at the end of the course. This exam supposed 60% of the final grade for b-learning students and 100% for traditional students. Hence, a comparison between methodologies independent of the contents and of the final exam of the course is made by contrasting the results for the samples R2 and Rb2 on the one hand, and R3 and Rb3 on the other. The differences reflect the difficulty of assessing the student's knowledge by means of an only exam of 2 hours in length against a continuous-assessment process that considers up to a total of 20 hours of assessed activities. Finally, the excellent acceptance of the b-learning activities by the students (Ramírez & Jiménez-Sáez, 2008) redounds to greater motivation by their part and better results.

5.3 Conclusions

This project of educational innovation exploits the capabilities of the program Moodle in the university education. Two subjects of applied nature were taught for two academic years following a b-learning method. A set of online and live activities in each teaching unit were developed by the students. In a first stage, theory and problem presentations were carried out; in a second, databases of theoretical questions; and finally, in a third, databases of applied questions. All these databases should have enough questions to avoid the students copying the answers from other classmate.

Number of passed students in different groups of students following a b-learning and traditional method has been compared. This study clearly shows the goodness of the b-learning methodology. These results confirm the difficulty of assessing the knowledge of the students in only exam of about 2 hours in length against a continuous-assessment process. Finally, the excellent acceptance of all these activities by the students must be highlighted, fact that redounds to greater motivation by their part.

6. Efficiency and Quality

From its beginning, the university is devoted to the task of generating, preserving and disseminating knowledge. However nowadays, new social realities influence its labor. Among them, the democratization and globalization of education, the development of ICT, and the development of the knowledge society can be highlighted. Inside this whirl of new ideas, the university faces up to the problem to define new standards in all educational processes. Undoubtedly, the concerns of quality and efficiency are of primary importance in these new models to follow. To draw conclusions about these two concepts is difficult in education. Unlike the economy, in education it is very difficult to specify the outputs to measure since educational systems so often in practice have no single well defined function (Sheenan, 1973). Besides, quality and efficiency mean different things to different people involved in the educational process: students, parents, teachers or politicians. In this chapter, the principal meanings of these two words are basically drawn from the industry and economy. Quality is to reach the conformity with the requirements and the customer's satisfaction (Crosby, 1979). In education, these requirements are described in the education guide. Efficiency is the achievement of the optimum outcome from a mixture of inputs in the right proportions. In education, the inputs are all the factors of the educational process, and the outcome is the level of requirements attained by the students which should be optimized as a function of their study time.

6.1 Student's Assessment

The assessment procedure of this b-learning methodology compared with the traditional assessment from only one exam is analysed from the point of view of the efficiency. Our learners took an overall exam at the end of the course. The mark of this exam would assess the student's work in the subject in the traditional methodology. On the contrary, the b-learning methodology involves a continuous assessment of the student's work. All activities developed by this throughout the course included exams must be assessed and taken into account in his final mark. The mark in a certain activity must be weighted according to its difficulty or devoted time to the same by the student. Therefore, more difficult or longer activities must be more valued.

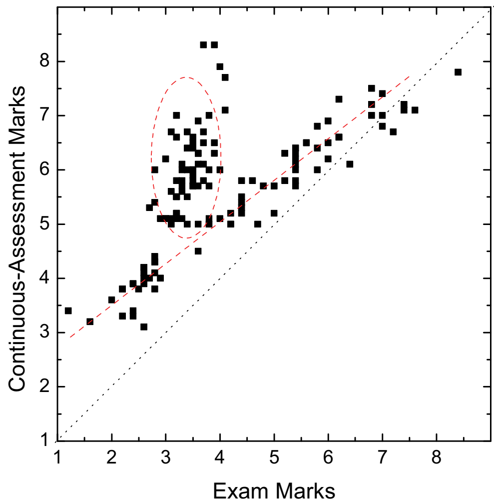

Fig. 7. Marks in the overall exam and marks obtained by the same student in a continuous-assessment procedure including this exam, both are in a scale from 0 to 10.

	Mean	Std. Deviation	1	Cronbach's Alpha
(1) Exam Marks	4.030	1.4169		.791
(2) b-Learning Marks	5.673	1.1281	.672	

N=140; *p<.001

Table 1. Pearson product-moment correlations between Exam Marks and b-Learning Marks. The mean, standard deviation and a measure of the scale reliability through the Cronbach's Alpha are also shown.

In Fig. 7, marks of the same student obtained by the final exam and by this exam plus the set of activities for all the students of Physics I and Physics II (course 2006-07) are compared. This figure shows as the academic achievement of most students improves if the assessment procedure analyses more in detail all their work and does not limit itself to valuing an only exam, especially for an important number of students with marks lower than five (five is equivalent to pass, see the ellipse in Fig. 7). This set of values shows neither a linear behavior (best fit line appears in red) nor a beforehand predictable behavior. The result is a correlation value smaller than 1, specifically 0.672 (see Table 1). This table shows different statistical variables of both samples. The efficiency of the b-learning assessment procedure is notably higher, since the mean mark of the set of students improves.

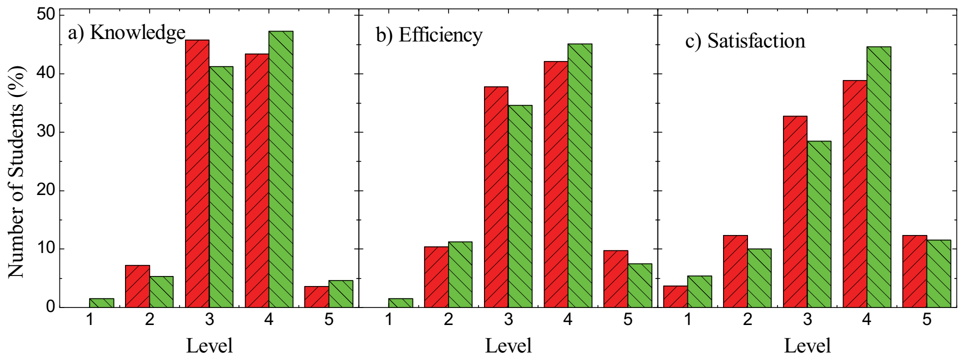

Fig. 8. Assessment of the students' perceived knowledge (a), efficiency (b) and satisfaction (c) on the subjects: Physics I and II (course 2007-08).

6.2 Quality and Efficiency

Different authors (Juran & Gryna, 1995) compare the educational institutions to factories providing a basic service, that is, the education. Students are the raw material; teaching is the process; and the graduate, the final product. This point of view considers the quality as agreement with the specifications. On the other hand, other authors (Moneen, 1997) liken the educational system to a productive activity. This activity gives rise to 'outputs': the obtained learning, and 'outcomes': the student's satisfaction. From this point of view, the quality is seen as an agreement with the specifications and besides as a satisfaction of the customer necessities. In this latter sense, a study has been carried out by trying to analyze if the b-learning method is capable of providing a quality education in engineering.

A total of 166 students enrolled in Physics I and 133 students in Physics II are the statistical sample of this study (course 2007-08). These students had red the subject before, that is, they were repeating it. In this work, whereas efficiency is measured directly, two aspects are used to value the quality (Jiménez-Sáez & Ramírez, 2008): on the one hand, the achieved learning as perceived by the student (Richmond et al., 1987); and on the other hand, the satisfaction of this (Ponzurick et al., 2000). By means of a survey, students have valued knowledge, efficiency and satisfaction in a scale of five levels from very low (=1) to very high (=5), just as some authors recommend (Lisstz & Green, 1975). Percentage histograms of these variables are shown in Fig. 8. The completed statistical analysis has been descriptive, since our aim has only been to find out trends in the students' behavior.

Means for the analyzed variables show a value very close to 3.5 (middle-high), slightly smaller for knowledge, intermediate for efficiency and slightly larger for satisfaction. Hence, this methodology is followed in all aspects well enough by the students. The standard deviation (about 1.4) is slightly smaller for knowledge, intermediate for satisfaction and slightly larger for efficiency. Therefore, efficiency is the more widely-spread variable. Better results are obtained in Physics II, due probably to that, at the beginning of the course, the ratio of passed to failed students in Calculus is 1:2 for Physics I and 1:1 for Physics II. The subject of Calculus has as main objectives to have a good grasp of derivatives and integrals. Fig. 9 compares the theory and problem knowledge as perceived by the students in a scale of five levels from very low (=1) to very high (=5). It is worth emphasizing the success of this methodology, since the problem knowledge is larger than the theory knowledge. In the b-learning method, the student is assessed by calculated questions extracted from a database through the program Moodle (course 2007-08). In a previous strategy, the student was assessed by a more reduced set of problems solved individually or in group and delivered by hand (course 2006-07). In general, the effort to solve these problems was replaced by the copy of the resolution. The main result is that the perceived problem knowledge was smaller than the theory knowledge (Ramírez et al., 2007).

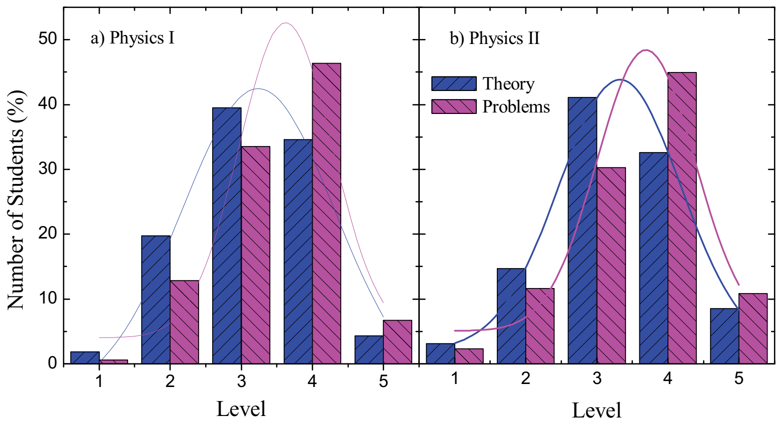

Fig. 9. Assessment of the theory and problem knowledge as perceived by the student for the subjects: Physics I (a) and II (b) and adjustment to a gaussian curve.

6.3 Dependence of the Satisfaction

In this section, factors, such as, motivation, study time, perceived learning or satisfaction, have been connected each other. A total of 149 repeat students enrolled in the subjects of Physics I and Physics II took a survey (course 2006-07). They assess these four aspects of the learning process in a scale of five levels from very low (=1) to very high (=5). The statistical analysis includes a study of the correlations among variables and the reliability of the scale. The research has not been exhaustive, but it has only tried to find out trends in the students' behavior; since, on the one hand, the number of data is not excessively large, and on the other hand, some assumptions like the normality of the distributions are not verified excessively well. These calculations have been carried out with the statistical package SPSS (Pallant, 2003) and the results are shown in Table 2. Means for the analysed variables show a value close to the high level (value = 4). These means are higher in motivation and study time and lower in satisfaction and knowledge. According to the standard-deviation values, the satisfaction and motivation are the more widely-spread variables. The Cronbach's Alpha coefficient is above 0.7, so the scale can be considered reliable with our sample. Correlation has been used to explore the relationship among the group of variables. The strength of the correlation between the motivation and the study time is small, between the satisfaction and the knowledge is large, and between the rest of variables is medium (Pallant, 2003).

	Mean	Std. Deviation	1	2	3	Cronbach's Alpha
(1) Motivation	3.81	.833				.712
(2) Study Time	3.95	.791	.253**			
(3) Satisfaction	3.74	.903	.482*	.313*		
(4) Knowledge	3.37	.693	.339*	.309*	.605*	

N=149; *p<0.001; **p=0.002; ***p=0.035

Table 2. Pearson product-moment correlations between measures of Motivation, Study Time, Satisfaction and Perceived Knowledge. Means, standard deviations and a measure of the scale reliability through the Cronbach's Alpha are also shown.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.678*	.460	.448	.671

Model 1		Unstandarized Coefficients		Standardized Coefficients
		B	Std. Error	Beta
	(Constant)	.005	.368	
	Motivation*	.323	.071	.298
	Study Time	.104	.074	.091
	Knowledge*	.620	.087	.476

*p<0.001

Table 3. Multiple correlation coefficient R, unstandarized and standardized regression coefficients (B and Beta respectively) and errors. Predictors are Constant, Knowledge, Study Time and Motivation and dependent variable is Satisfaction.

From the pedagogical point of view, teacher could think that greater motivation makes student devote more time to the study. The consequence of this greater dedication is the perception of a larger amount of acquired knowledge. The carried out work together with the acquired knowledge would produce a satisfaction feeling in the student. From the statistical point of view, the relationship between knowledge and satisfaction is undoubtedly clear. However, the relationship between motivation and study time and between study time and perceived knowledge seems to be influenced by more factors. Below, the strength of the relationship between the satisfaction and the rest of variables (model 1) is explored by a procedure of standard multiple regression. The main results of the adjustment obtained by means of the code SPSS for the model 1 are shown in Table 3.

Our model explains 46.0 per cent of the variance in satisfaction. This is quite a respectable result. The model in this example reaches statistical significance since in the ANOVA test of the null hypothesis (R equals 0) p<0.001 (not shown in table 3). From the standardized coefficients, one can conclude that knowledge makes the strongest contribution to explain

the dependent variable, approximately the double of the motivation. The beta value for study time was 0.091 indicating that it made less of a contribution, besides p-value (0.164) is larger than 0.05, with the result that the variable is not making a significant unique contribution to the prediction of the dependent variable.
Continuing the main aim of this section of analyzing what factors of the educational process determine the answers of the students with regard to their satisfaction, a survey on this topic was taken among 299 students of the subjects: Physics I and Physics II (course 2007-08). In the abscissa axis of Fig. 10, different factors that take part in the learning process, i.e. the inputs, were selected by the students as determinant in their satisfaction. These factors were chosen since, in our opinion, their influence may be important on this variable. Two factors, acquired knowledge and motivation, were previously used in the model 1.

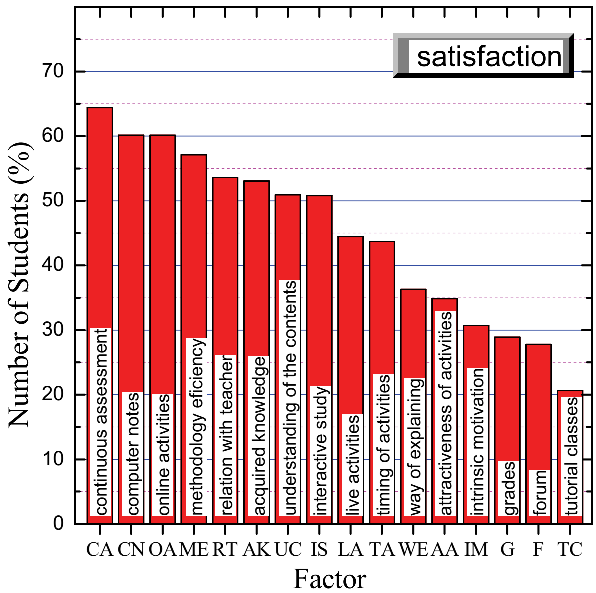

Fig. 10. Dependence of the satisfaction on different factors of the teaching process.

As shown in Fig. 10, the dependence of the satisfaction is practically linear. In a range of 10%, there are a total of eight decisive factors, namely in order of importance: the continuous assessment, the computer notes, the online activities, the efficiency of the methodology, the relation with the teacher, the acquired knowledge, the understanding of the contents and the interactive study. Two aspects are worth mentioning: the strong interdependence of efficiency, knowledge and satisfaction, and the influence of the human factor in education represented by the relation with the teacher. Two factors: the live activities and the timing of activities occupy an intermediate level. And finally, the teacher's way of explaining, the attractiveness of activities, the intrinsic motivation, the grades during the course, the forum, and the tutorial classes are factor of smaller order of importance. Curiously, grades, fundamental objective of the student during the course, occupy one of the smaller levels of importance. Undoubtedly, this result requires a deeper psychological study.

A wider study indicates that several factors can be dismissed as parameters of first order of importance in variables, such as, knowledge, efficiency or satisfaction (Jiménez-Sáez & Ramírez, 2009). These are: the forum, the tutorial classes, so little used by the student, and the motivation, maybe because this attitude is supposed in a repeat student with aspirations to follow in the degree. Physics I and Physics II were taught by different teachers, although following the same methodology. This fact is remarkable given that the maximum difference between the number of students in Physics I and in Physics II for a certain factor does not rise above 10% in general. Exceptions are the understanding of contents, where the difference slightly rises above 10%, the intrinsic motivation and the relation with the teacher, in which it rises above 20%, and the teacher's way of explaining, above 25%. These two latter factors reflect clearly the influence of the teacher.

6.4 Conclusions

The spreading and very rapid development of new technologies has increased the variety of pedagogical models usable for teaching. In this sense, the b-learning method has arisen as a new methodological approach. This strategy has been used in two subjects of Physics on repeat students. They received computer notes, attended at multimedia presentations, and solved quizzes with theory and problem questions.

Histograms of perceived satisfaction, knowledge and efficiency were carried out from a survey among students. Their opinion on these three variables intimately related to the teaching process has been good on average. The assessment procedure has also been analysed from the point of view of the efficiency. The academic achievement of most students improves, if the assessment procedure analyses in detail all their work throughout the course, and does not limit itself to an overall exam, especially for an important number of students with marks lower than the pass. A statistical study to connect each other pedagogical variables, such as, motivation, time study, knowledge or satisfaction has shown interesting results. The satisfaction depends especially on the perceived knowledge, but not on the study time. The continuous assessment, the methodology efficiency, the online activities and the computer notes are the factors more influencing the satisfaction.

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The widespread deployment and use of Information Technologies (IT) has paved the way for change in many fields of our societies. The Internet, mobile computing, social networks and many other advances in human communications have become essential to promote and boost education, technology and industry. On the education side, the new challenges related with the integration of IT technologies into all aspects of learning require revising the traditional educational paradigms that have prevailed for the last centuries. Additionally, the globalization of education and student mobility requirements are favoring a fluid interchange of tools, methodologies and evaluation strategies, which promote innovation at an accelerated pace. Curricular revisions are also taking place to achieved a more specialized education that is able to responds to the society's requirements in terms of professional training. In this process, guaranteeing quality has also become a critical issue. On the industrial and technological side, the focus on ecological developments is essential to achieve a sustainable degree of prosperity, and all efforts to promote greener societies are welcome. In this book we gather knowledge and experiences of different authors on all these topics, hoping to offer the reader a wider view of the revolution taking place within and without our educational centers. In summary, we believe that this book makes an important contribution to the fields of education and technology in these times of great change, offering a mean for experts in the different areas to share valuable experiences and points of view that we hope are enriching to the reader. Enjoy the book!

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