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The role of new technologies in the learning process: Moodle as a teaching tool in Physics

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A B S T R A C T

In this work we present an overview of the undergraduate online Physics course that we have implemented in the Moodle platform. This course has been developed as an enhancement of the face-to-face courses. The aim of this course is to create an online learning community which helps both teachers and students to have a virtual space where we can share knowledge through different kinds of supervised activities, chats and forums. As we will show in this paper, the students' response to this initiative has been very good: the online Physics course helps them to reinforce their abilities and knowledge.

1. Introduction

New technologies (in particular, the internet) provide teachers with many interesting tools that can be used to improve the teaching–learning process. The usefulness of these tools makes important for teachers to have more information about the advantages and possibilities of using technology in the classroom (Kaminski, 2005), as well as about the results derived from their application.

Besides the fact that the internet is a vast source of information, there are some specific web-based applications that are conceived to be used as a teaching resource. These applications (often called e-learning platforms) allow teachers to provide the students with material of different sorts, as well as to interact with them in real-time. They also allow teachers to follow the evolution of the learning process and to know the performance of each student in specific tasks.

E-learning platforms (also known as a virtual learning environment (VLE)) are especially useful when teaching Science in general and Physics in particular. They allow implementing objects of many kinds such as: videos, mp3s, text documents, scanned images, links to other web sites or animations which can be used to show dynamically many physical situations and concepts that are often difficult to apprehend by the students.

A virtual learning environment (VLE) Weller, 2007 is a software system designed to support teaching and learning. A VLE typically provides tools such as those for assessment, communication, uploading of content, return of students' work, administration of student groups, questionnaires, tracking tools, wikis, blogs, chats, forums, etc. over internet.

A VLE is a computer program that facilitates the so-called e-learning (electronic learning). Such e-learning systems are sometimes also called learning management system (LMS), course management system (CMS), learning content management system (LCMS), managed learning environment (MLE), learning support system (LSS) or learning platform (LP); it is education via computer-mediated communication (CMC) or online education.

In the United States, CMS and LMS are the more common terms, however LMS is more frequently associated with software for managing corporate training programs rather than courses in traditional education institutions.

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In the United Kingdom and many European countries the terms VLE and MLE are used more frequently; however, these are two very different things. A VLE can be considered a subsystem of an MLE, whereas MLE refers to the wider infrastructure of information systems in an organization that support and enable electronic learning.

There are many e-learning platforms http://www.brandon-hall.com/publications/lmskb/lmskb.shtml. Some of them are commercial software, whereas others are open-source software (OSS). Among the first category are WebCT and blackboard http://www.blackboard.com/us/index.bbb (that merged in 2005). Examples of open-source platforms are Moodle http://moodle.org/, Ilias http://www.ilias.de/, Atutor http://www.atutor.ca/ and Claroline http://www.claroline.net/. All these applications have common features, but some of them are more flexible and complete in specific aspects, such as role assignments, chats management, etc.

The Universidad Politécnica de Madrid (UPM) (http://www.upm.es) has placed at lecturers' disposal the Moodle platform to develop online courses proposed as a complement to the classroom lessons. Development of Moodle is undertaken by a globally diffused network of commercial and non-commercial users, spearheaded by the Moodle Company based in Perth, Western Australia, although its original developer is Martin Dougiamas (http://dougiamas.com/). One of the most striking features of the design approach favoured by Moodle is the ease with which course materials can be developed and refined in an iterative fashion (Berggren et al., 2005).

The University brings professors technical support and also manages the students' database. Taking advantage of this opportunity, we have implemented in Moodle an undergraduate Physics online course as an extension of the face-to-face courses. Our aim is to provide students with additional material (web-based homework) that helps them to deep into the concepts and subjects developed in the classroom.

In this work, we show the main features of our online Physics course (implemented in Moodle) as well as the conclusions derived from this experience. First, we will introduce a description of the main features of our online Physics course. Then, we will examine the results we have obtained, and the students' response to this initiative.

2. Background

Moodle has been used as a LMS platform for sharing useful information, documentation, and knowledge management in research projects, yielding important benefits to the researchers (Uribe-Tirado, Melgar-Estrada, & Bornacelly-Castro, 2007). Data mining techniques have also been addressed as complementary systems to LMS, and in particular to Moodle, where results are achieved through the use of associators, classifiers, clusterers, pattern analyzers, and statistical tools (Romero, Ventura, & García, 2008). The transition from commercial LMS to open-source systems (such as Moodle) is a growing trend. The spread of these online technologies has been widely analyzed at faculty level, as for example in San Francisco State University (SFSU), where the 70% of all courses use online technologies (Beatty & Ulasewicz, 2006). Moodle platforms are under continuous evolution. Different debates and forums are being set up in order to maintain an open dialogue between lecturers and Moodle developers. The achievement of a transparent integration between both "worlds" is needed for future versions (Berggren et al., 2005).

Teachers can also improve Moodle platform by implementing web-based peer assessment. These works are used to enhance the student cognitive schema, helping them to construct their knowledge, and promoting the student positive attitudes towards discussing and cooperating with peers. It is evidenced that students increase their skills to undertake learning by using the information technology.

The usage of computers in Physics instruction began in the seventies (Chonacky, 2006). Since then, there have been many studies that analyze the effectiveness of new technologies applied to teach Physics (for an extensive revision of these results, see for instance (Kenny, Bullen, & Loftus, 2006).

There is a wide debate about the influence on computer-assisted education in Physics courses (Kenny et al., 2006). Some authors consider that computational Physics provides a broader and more flexible education than a traditional Physics course. Moreover, they consider that teaching Physics as a scientific problem-solving paradigm is a more effective and efficient than using the traditional approach (Landau, 2006).

3. Materials and methods

In Moodle, all the available information within a course (for a specific subject) is organized in separate blocks. The first block is always devoted to general and administrative information, as well as support contents about the course: timetables, teachers, news, forums, chats and so on. The remaining blocks can be organized in different ways. In our course, each block corresponds to a specific area of the subject. We have organized it as follows:

- *First and second block*: teachers, timetables, general forum, chats (one for each teacher), exams, lab description, course planning, homework (see Fig. 1).
- *Third block*: kinematics, single-particle dynamics
- *Fourth block*: many-particle dynamics, rigid body
- *Fifth block*: electrostatics
- *Sixth block*: magnetism
- *Seventh block*: thermodynamics.

This syllabus is the same as the one distributed the first day of class, so there is no difference between the CMS-oriented syllabus and the one used during the face-to-face course.

Chats and forums added to the first block are conceived as an online space for discussion and a real-time source of information and news. First, students have up-to-date information about the different activities they have to carry out in order to follow the course, i.e. lab sessions, support lessons. On the other hand, they can post questions and begin a debate about doubts and concepts learnt in the classroom.

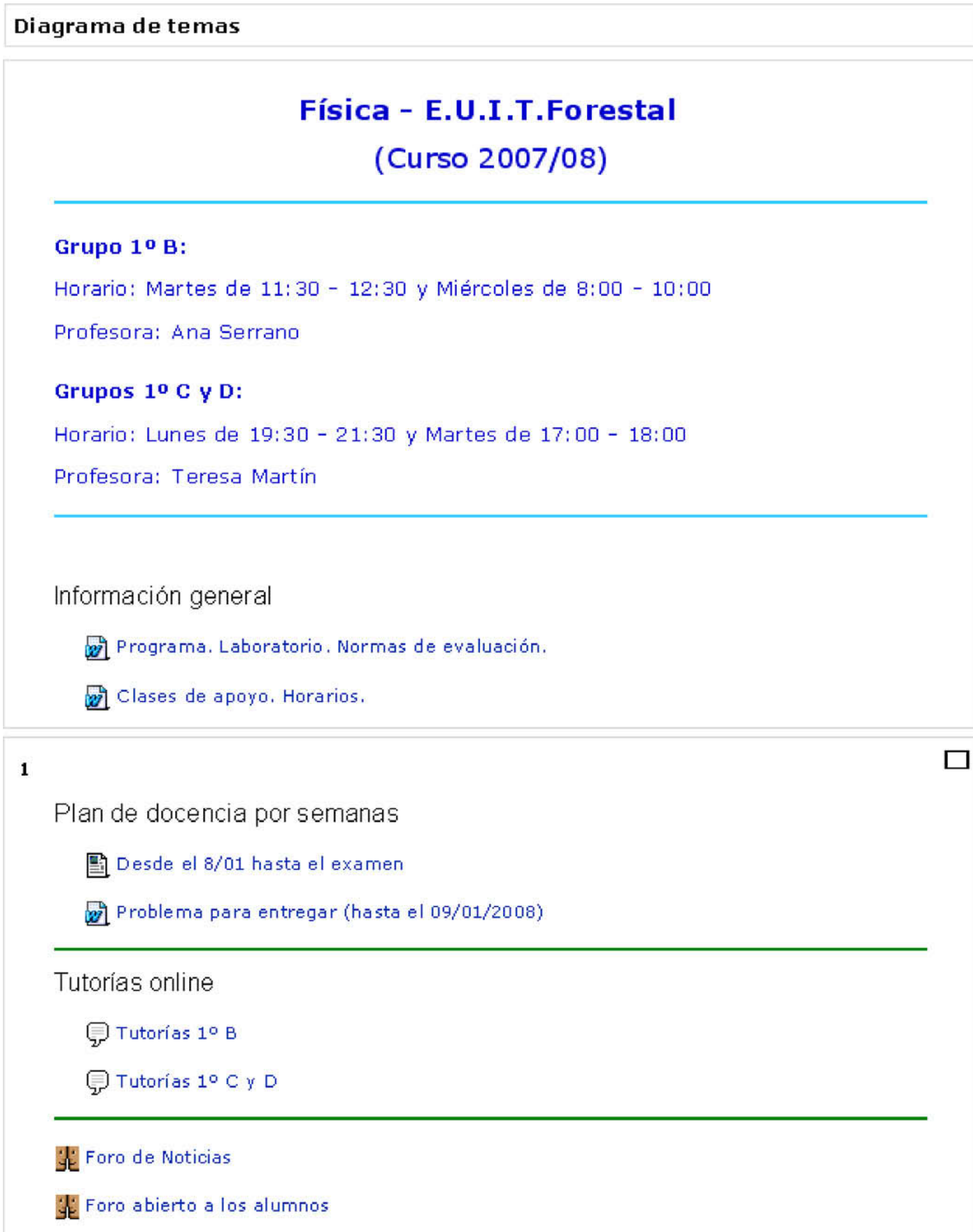

Fig. 1. Physics online course first block's screenshot.

The course planning is a section that we update each two weeks. There, we post the contents that will be developed in the classroom during that period, as well as the problems and exercises that we will solve during the same period. This way the students can know in advance which concepts are going to be treated in the classroom, so they can read about them and they can also try to solve the problems by themselves before they attend the course. It is also very useful for students that did not pass the exam in previous years and want to put the stress only on specific concepts.

In the homework section, we propose some out-of-classroom activities. These activities consist of a series of problems related to the concepts explained during the lessons. We then correct them and we give them back to the students so they can improve the aspects of the problem that posed more difficulties to them. The idea is to follow the performance of the students from the beginning to the end of the course.

Besides chats and forums, we have chosen the following items from the different course material elements that can be implemented in Moodle, in order to include them in each theme block (see, for instance, Fig. 2).

- Quizzes with different kinds of questions
- Collections of problems and exercises
- Lecture notes
- Java applets.

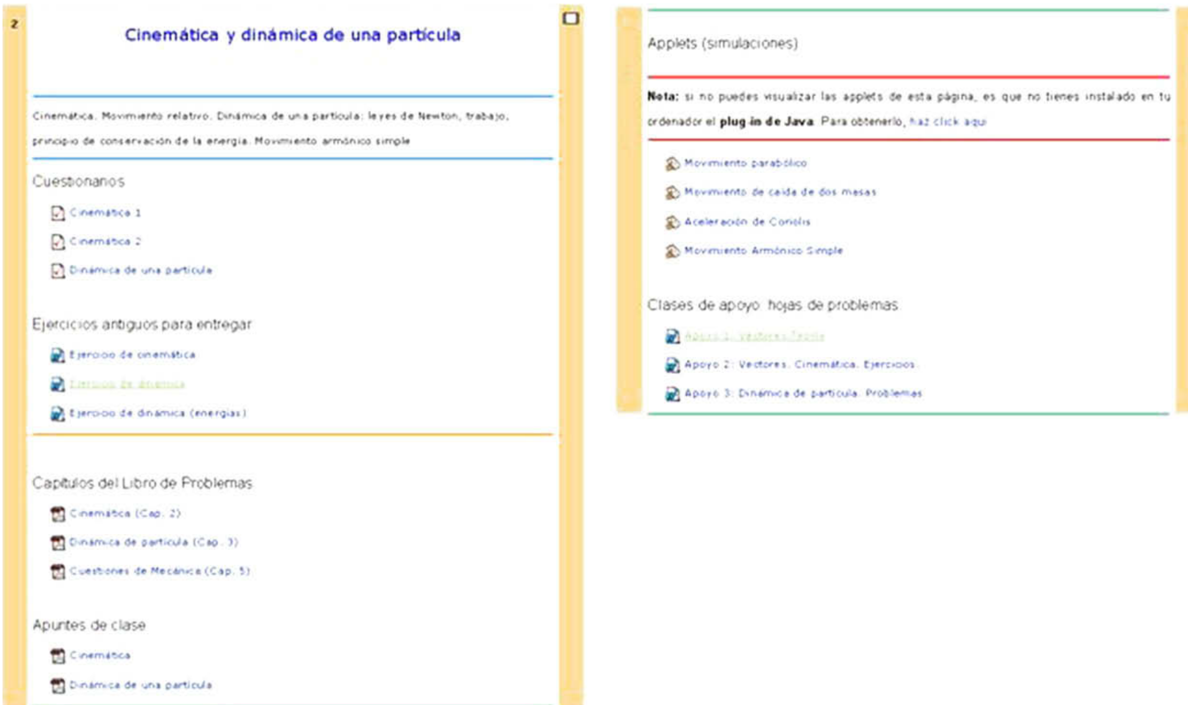

Fig. 2. Screenshot of the first theme block.

3.1. Quizzes

Quizzes are a useful tool for students to test their level of knowledge. All the questions posed there are based on basic concepts of Physics previously explained in the classroom. Moodle provides a wide range of quiz types. For our online course we have chosen questions that can be of two types: true/false and multiple-choice questions. Apart from the questions themselves, there are many parameters one can adjust in the quizzes: the date at which the quiz is available, the time they have got to solve it, the number of tries; with the wrong answers the teacher can send a comment to the student. They know the score they have gotten in real-time. When a quiz is created, one can define the number of tries one student can do. Students can therefore try again when they think they have improved the knowledge they have on these issues. Each time the students try to solve one of them the questions appear in different order. In the following figure (Fig. 3) an example of a true/false quiz item is shown.

3.2. Collections of problems and exercises

One crucial aspect of the process of learning Physics is to develop the ability to solve problems that represent different (more or less complex) physical situations. Students usually find it difficult to apply the laws and equations they have seen in the classroom, so it is important to provide them with a collection of exercises that help them to accomplish this task. For this reason, we have uploaded to Moodle a complete set of problems, ranging from mechanics to thermodynamics.

3.3. Lecture notes

We are aware of the fact that there is a large amount of good bibliography on undergraduate Physics; however, we think it is also useful for the students to have a collection of lecture notes on this subject. In these notes we can put the stress on specific issues that we find particularly hard to assimilate by them, based on our own experience of more than ten years teaching Physics. On the other hand, as many of the students work and study at the same time and cannot attend all lessons, by means of these notes they have a way to follow and prepare the course, even while they cannot attend them for short periods of time.

3.4. Java applets

Presentations in a standard format (such as scripts, Java applets, movies and flash animations) are an excellent tool to understand the laws of Physics by means of dynamic simulations of physical problems.

Undoubtedly, applets are one of the most successful resources in teaching Physics. The applets, as simulations, computer experiments and problems, require the students to observe an animation and sometimes make measurements of relevant parameters (Franco, 2000).

Although Java applets are not specific for Moodle (they can be executed within any supported web browser), within Moodle they can be used to propose an entire activity based on them. Watching an animation is not just a passive activity: students have visual and dynamic information about a physical system that they have to understand (Fig. 4).

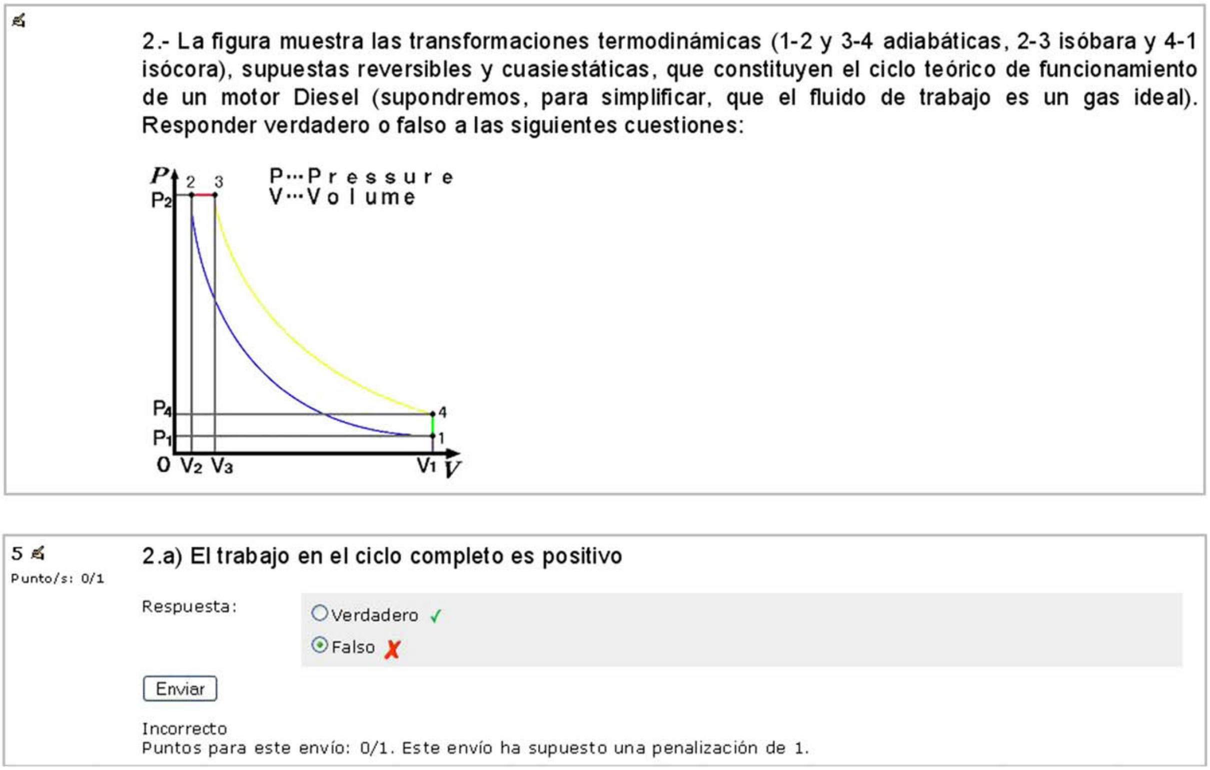

Fig. 3. An example of quiz. The student can know his score after he has answered the questions.

In order to prevent any negative effects of the use of Moodle, such as the difference in theoretical knowledge and practical skills or the fact that some students watch Java applets just to carry out experiments, we used the applets to pose exercises in which the students could adjust the relevant parameters to different values, observe the behaviour of the system under different conditions and then answer specific questions about this system. Thus, to answer these questions they have to understand the Physics underlying the situation they are watching at.

Once the student has sent his task, the teacher can make him some suggestions or comments about his work via the personal message utility that Moodle has or simply via email.

The internet is an extensive source of these animations (see, for instance http://www.sc.ehu.es/sbweb/fisica/, http://ocw.mit.edu/OcwWeb/web/home/home/index.htm, http://www.upscale.utoronto.ca/GeneralInterest/Harrison/Flash/, and http://www.walter-fendt.de/ph11e/. We have adapted some of them to the needs of our course, in such a way that we can use the animations to prepare web-based homework activities. Our aim is to produce our own simulations in a near future.

3.5. Information available in Moodle

Moodle provides a lot of information about the student's usage of the platform and also about their performance. This information can be obtained for a single person, for an entire group of people or even for all the students at a global level.

On an individual basis, the teacher can know all the activity carried out by each student in the platform: number of visits, time spent doing each task, scores, etc. This information can be retrieved numerically or graphically (see, for instance, Fig. 5).

Numeric information can be retrieved both within the platform itself or downloaded in a file suitable to be used with a spreadsheet application (i.e. Microsoft Excel). This feature allows the teacher to extract useful information about the course. For example, one can build a histogram for different kinds of data, as the scores obtained by the students at a specific quiz, as shown in Fig. 6.

Moodle also automatically calculates some indicators that give an idea about the difficulty of the different activities. One of these indicators is the so-called 'difficulty index', defined as the mean score obtained by the users at a specific item of a quiz divided by the maximum score obtained by a single student. This information can then be used to improve the quality of the different activities implemented in Moodle.

3.6. Interaction with the students

At the beginning of the academic year, we carried out a survey in order to know whether the students had access to the internet, and only one of them did not have an Internet connection at home. Anyway, this was only a partial problem, since at the faculty they have computers at their disposal. So every student had unlimited access to Moodle resources.

One interesting aspect of Moodle is the fact that it has some tools that make possible to give the students support and help while they carry out the activities proposed. For this purpose, apart from the chats and forums mentioned at the beginning of the section, it is possible within Moodle to send personal messages to users; this tool has proven to be very useful for students, as they can ask questions to their teachers and to other students in order to clarify specific aspects of the tasks they are performing. This is an important aspect of the learn-

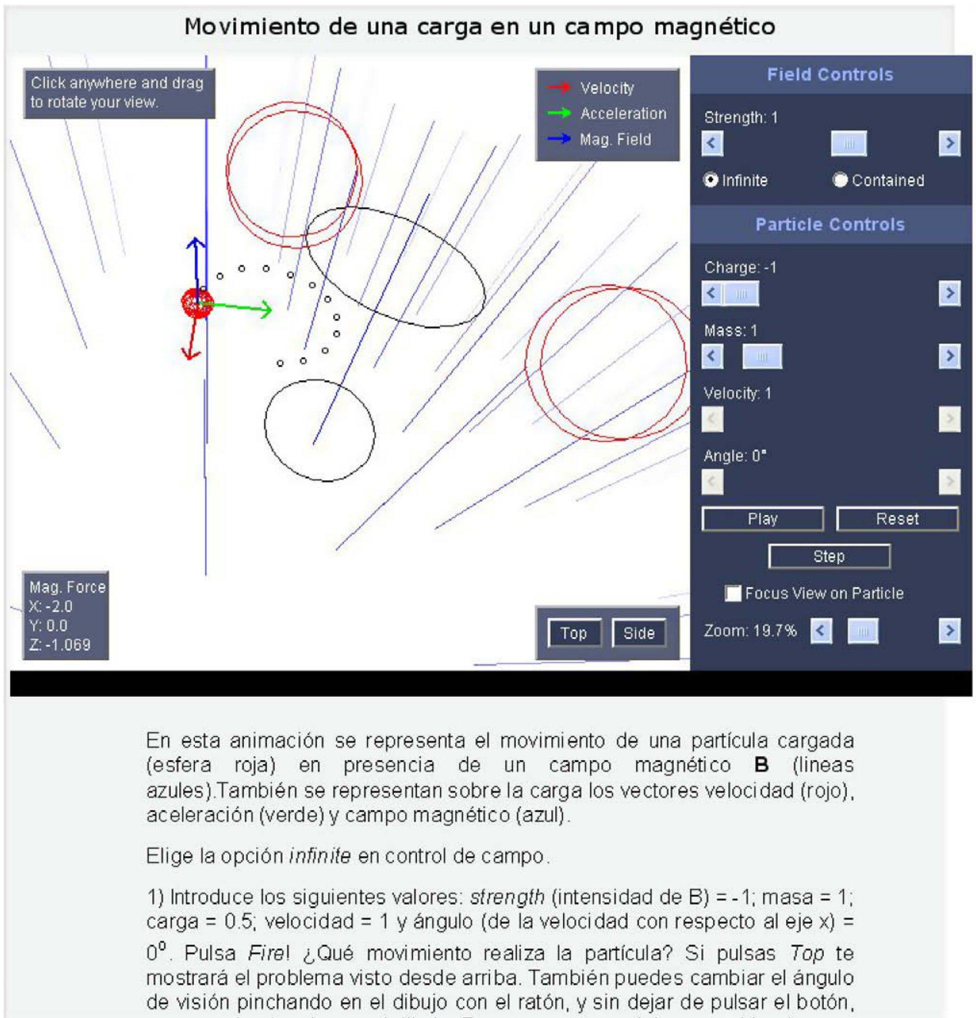

Fig. 4. Example of a task based on a Java applet.

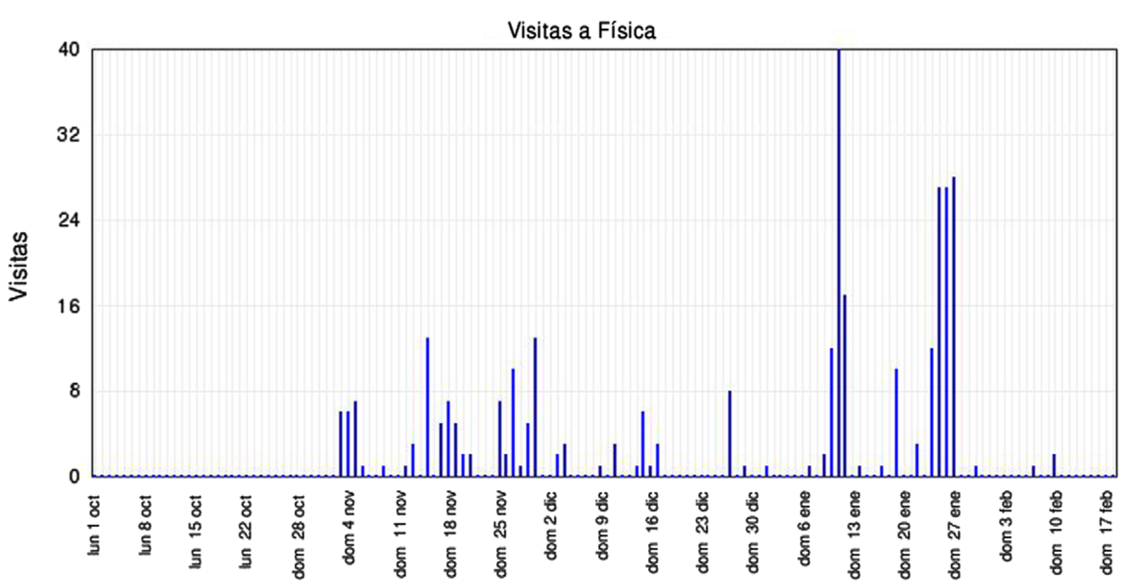

Fig. 5. Time evolution of the number of visits for one single student.

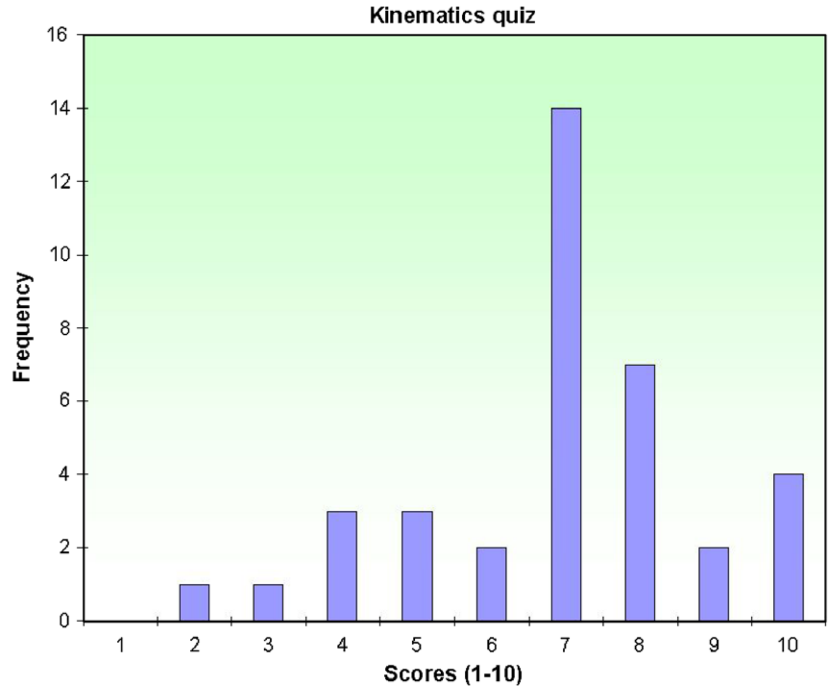

Fig. 6. Histogram of global scores obtained by the students in a quiz.

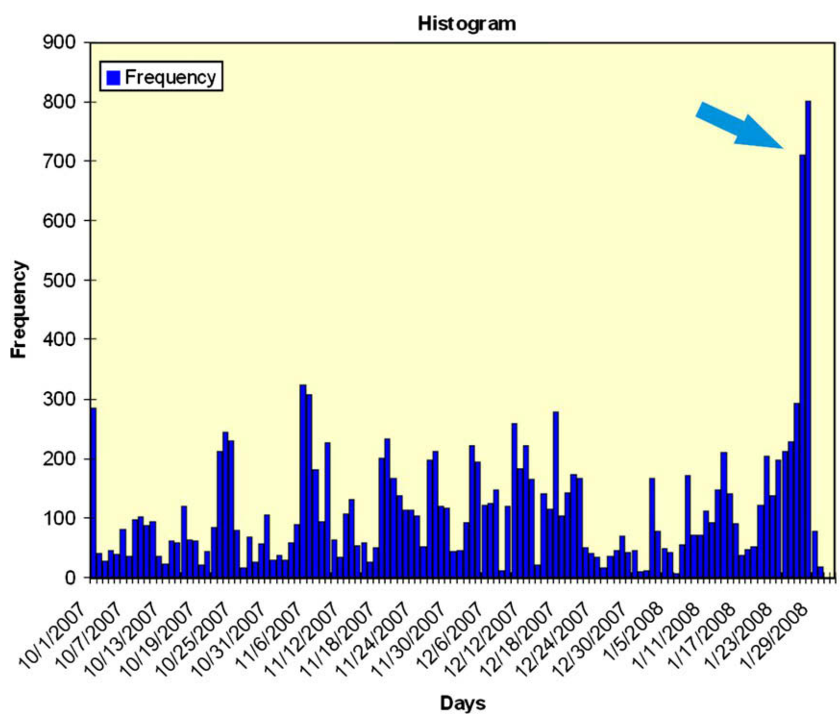

Fig. 7. Total daily visits to the Physics online course. The peak marked with the blue arrow indicates the number of visits the days before the exam (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.).

ing process, because the students feel more confident (Demirci, 2007) if they know that their teachers will answer their doubts and questions personally and privately.

In Fig. 7 the total number of visits is shown. The peak marked with a blue arrow represents the number of visits the days prior to the semester exam. We can clearly see that the students find this tool useful, as they resort to it when they are preparing the exam.

4. Results and discussion

In this section, we are going to present some results concerning the students' performance during the first semester of the Physics course.

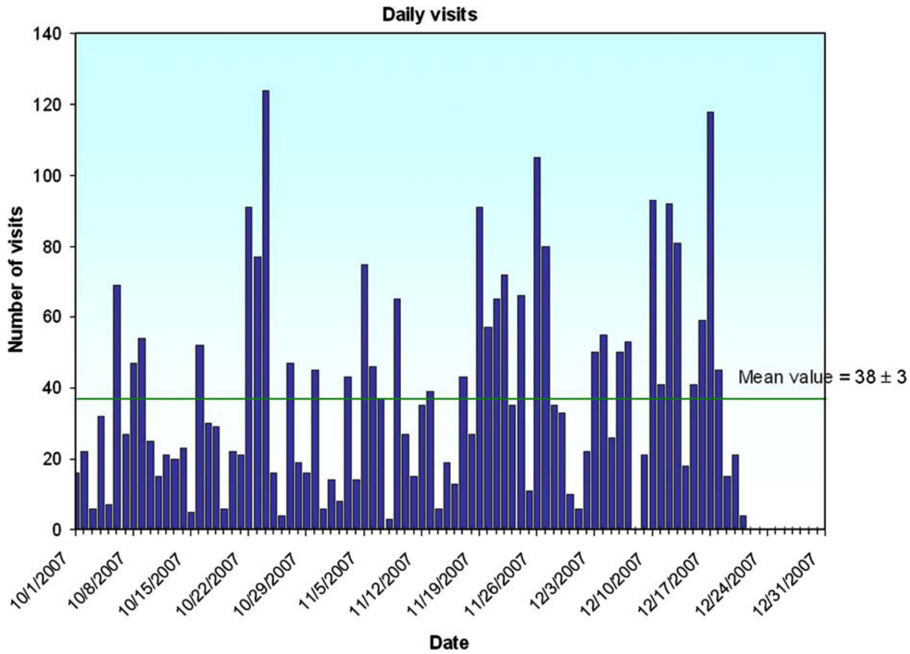

Fig. 8. Daily visits to the online Physics course since the beginning of the academic year.

First of all, it must be pointed out that, in order to have more accurate results, it would have been desirable to compare the results obtained by the students in the exam with the results obtained by a control group with students that accomplish the final exam but do not use Moodle. Unfortunately, due to the internal organization of our faculty, this experiment could not be done. In the results here presented all the students had the possibility to use the virtual course, and the decision of whether to use it or not was left at their will. Probably in the future we will have the opportunity to carry out a more controlled experiment.

In the figure below Fig. 8 the total number of visits to the online course as a function of date is shown. In this figure we have also included the mean value of the total number of daily visits, which is 38 ± 3. First, we can see that there is an ascending tendency which becomes clearer in Fig. 9, where we have plotted the moving average for one-week periods.

The second fact that catches the eye in Fig. 8 is that there are some peaks at certain dates. These peaks can be related to the dates when we uploaded to Moodle the lecture notes (see Fig. 10). Lecture notes are, by far, the most visited resource of the online course.

4.1. Students' performance

The total number of students that made the semester exam was 52. Half of this quantity passed the exam (i.e., obtained a score of more that 4.5 over 10). This number might at first sight seem discouraging; unfortunately such failure rates are a common issue in the Spanish

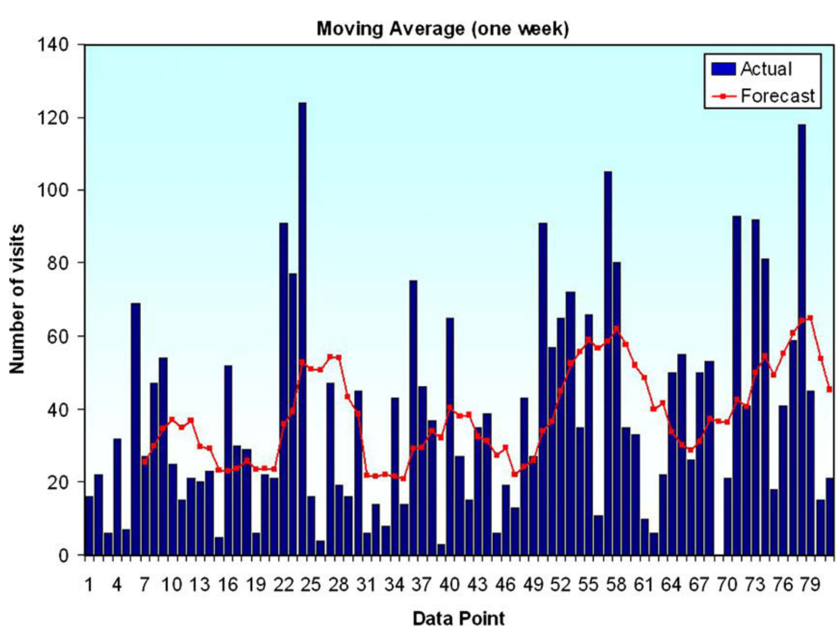

Fig. 9. Moving average (for one-week periods) of the total number of visits.

Table 1
Scores and number of visits to Moodle for all the students that carried out the semester exam

Total number of students: 52			
Score ⩾ 4.5 (over 10)	26	Score < 4.5 (over 10)	26
Moodle users	**24**	Moodle users	12
Average number of visits	107 ± 20	Average number of visits	68 ± 24

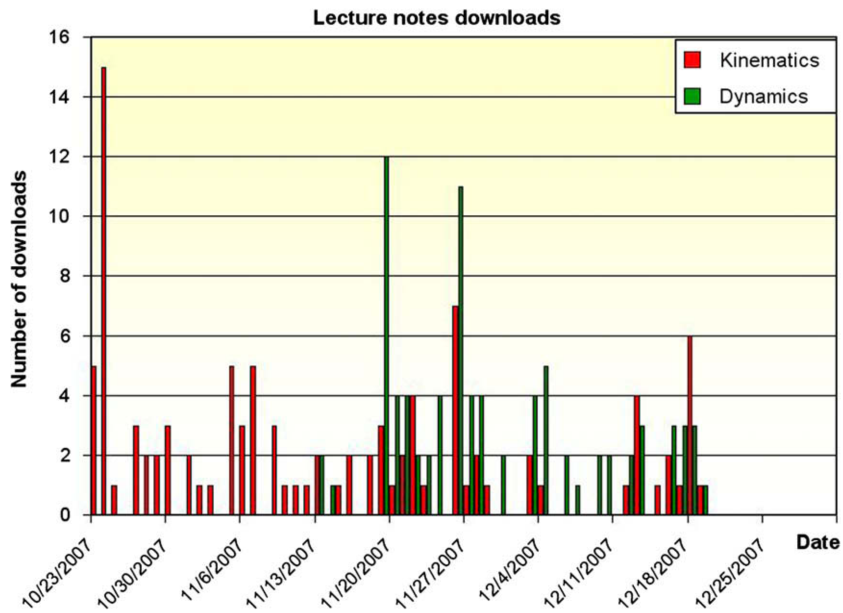

Fig. 10. Downloads of the lecture notes as a function of time.

University. It has to be kept in mind that about half of the students that followed the course during the first semester had never studied Physics before. Moreover, some of them did not have the basic knowledge on Mathematics necessary to understand basic concepts such as vector calculus. This fact is due to the curricular itinerary of the students. It is not mandatory in Spain to have followed a Physics course prior to their admittance into certain Science faculties. One example of this situation is the forestry engineering field, in which we are working.

The exam consisted of two parts: the first one was a theoretical section which included some conceptual questions. This is usually the toughest part for the students. The second one consisted of three practical exercises.

We have analyzed the number of visits to Moodle for the two groups: the group that passed the exam and the group of students that did not pass it. Table 1 summarizes the results obtained.

From the results presented in the previous table, one can see that within the group that passed the exam, 24 of 26 students were regular users of Moodle. This number drops to 12 (less than a half) for the students that did not pass it. The average number of visits is also higher within the first group. The relationship between both facts is the apparent: users of Moodle got higher scores in the exam.

One remarkable fact that we have observed is that the students who followed the virtual course (i.e., those students who did the quizzes and the applet-based exercises) got higher scores in the theoretical part of the exam than previous years. However, it is difficult to say if these students will become in the future the best professionals. At least it can be said that they have made a good usage of the tools that they have at their disposal.

Regarding the psychological factors involved is this experience; it is hard to say if there is an "effect of recognition" influencing the results. That is, the students are perhaps more inclined to work harder when they know that their teachers 'are available' at any time to support them and that causes their scores to raise high.

5. Conclusions

First of all, Moodle is a great way for teachers to organize, manage and deliver course materials. From the didactic point of view, the usage of multimedia tools to create attractive activities makes the learning process friendlier for students. As a consequence, these activities increase the interest of the students in the study of Physics. Teachers can provide students with a great amount of resources that usually they cannot show in the classroom due to the lack of time.

Moodle also makes easier the interaction with the students in real-time and also allows receiving their opinions and suggestions; as a learning community, Moodle makes possible for students to share their knowledge and difficulties, so they can help each other via forums and chats. Teachers can notice in which parts of the subject they have more difficulties to understand the concepts developed in the classroom.

At the beginning of the academic year, students were a bit reluctant to participate in this activity, probably because they were not used to face new tasks. Then, they gradually increased their visits to the site. We have noticed that, when we uploaded the lecture notes, they began to explore the other items previously uploaded in the platform; then they started doing the quizzes and they even suggested us some improvements. This is a key point, as it is very important that the students feel involved in their own learning process. We can also note that the number of visits to the platform is increasing over time which suggests that the students have interest in such e-learning techniques.

We have evaluated the improvement of the academic results derived from the use of this e-learning platform. The students who used Moodle regularly during the semester have obtained higher scores than the students who did not. So the impact for students of these web-based applications becomes apparent. Moreover, the students have transmitted us that their general feeling is that Moodle helps them to reinforce their abilities and knowledge. These results encourage us to continue with the improvement of our Moodle virtual space.

Many authors have reported about the use of web based resources in connection to General Physics courses at faculty level. In some of them, the results indicate that there was not a statistically significant difference in the average scores; only the homework performance scores based on assigned homework groups were improved. Overall, the perception of students of web-based homework testing was very positive (Crippen & Earl, 2007).

We have in mind to implement another Moodle course (that will be called 'Zero Physics') devoted to improve and homogenize the basic knowledge of the students who are in the freshman year at the University. This course will include some applets involving basic concepts about Mathematics, Physics and experimental techniques. One goal we would like to achieve is to avoid the 'fear' that the students sometimes feel when confronted to the animations for the first time: we have found that they are a bit reluctant to do these kinds of exercises, probably because they are not familiar with these resources. This goal could be achieved by introducing these animations during the first days of the face-to-face course.

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