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E - Learning Platforms in Physics Education

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1. Introduction

Nowadays, our world functioning is largely based on science and technology. Thus, we need technically literate citizens with complex problem-solving skills that allow them taking wise decisions and understanding the challenges we might face now and in the near future. However, it is a well known fact that student's learning efficiency of science in general and Physics in particular is not as good as expected.

Digital technologies provide researchers in general and teachers in particular with many interesting tools that can be used to improve, on one side, the flux and exchange of information and, on the other side, the teaching - learning process.

These resources, barely imaginable just a few years ago, open a vast field of possibilities that can be used to enrich the traditional classroom activities. Besides the fact that the Internet is a vast source of available information, there are some specific web-based applications that are devised to be used as a teaching tool. These applications (often called e-learning platforms) can be used to deliver online courses (where there is no face-to-face interaction with the student) or as a complement to the traditional lectures (blended – learning instruction).

With the aid of these online activities, the student is no longer a mere spectator of his learning process, but he can also participate, create his own studying schedule, exchange information with other students and interact with his instructor in real-time. On the other hand, the teacher himself can follow the performance of their students in specific tasks, and can give them support, feedback and assistance. This rich collaborative environment makes it easy to share information, experiences and knowledge.

In this chapter a review of the most relevant features of the e-learning platforms is presented, as well as an example of an online undergraduate Physics course implemented in the open-source software called Moodle. The students' response to this course will also be analyzed.

2. What is e-learning?

Electronic learning (or e-learning) is a type of technology-supported education/learning (TSL) where the medium of instruction is through computer technology, particularly involving digital technologies. In general, during an e-learning course, no face- to- face interaction takes place among instructors and students.

These digital technologies are widely used nowadays in a variety of different contexts. Some companies deliver training courses to employees and customers via web conferencing and applications such as WebEx (created by Communications Inc. and acquired by Cisco Systems in 2007). These products can be seen as an online classroom that has the advantages of eliminating travel and venue costs. With the aid of these tools instructors can engage learners with interactive features including polling, testing, hands-on labs, etc.
Besides the different online meeting utilities available in the market, there are also the so-called Virtual Learning Environments or VLE (see section 2.1 for an in-depth description of them) which allow delivering online courses.
However, online learning has its drawbacks. One of the main disadvantages is the lack of social interaction which is taken as given in conventional settings (Henzer & Procter, 2004). This creates a special need to motivate the less independent student. In order to override this problem, e-learning platforms can also be used to deliver courses that combine both the use of technology and regular methods of teaching. These kinds of courses are called blended instruction or, more generally, **blended learning** (b-learning).
In blended learning, one can take the advantages of the traditional teaching scheme (face-to-face lessons, lab sessions, guidance and coaching) and, at the same time, enhance the learning experience through a series of online activities that can be carried out by the students either on a fixed- schedule basis or in a more flexible way (see Fig.1).

2.1 E-learning platforms

E-learning platforms (also known as Virtual Learning Environments (VLE)) are designed to create online courses which allow both the interaction with the students and a collaborative learning experience, so learners can contribute to their own educational process (Weller, 2007). A VLE typically provides tools such as those for assessment, communication, uploading of content, return of students' work, administration of student groups, quizzes, tracking tools, wikis, blogs, chats, forums, etc., over the Internet.
A VLE is a computer program that facilitates the above mentioned e-learning (electronic learning). Such e-learning systems are sometimes 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.
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. Some of them are commercial software, whereas others are open-source software (OSS). Among the first category are for instance WebCT and Blackboard (that merged in 2005).

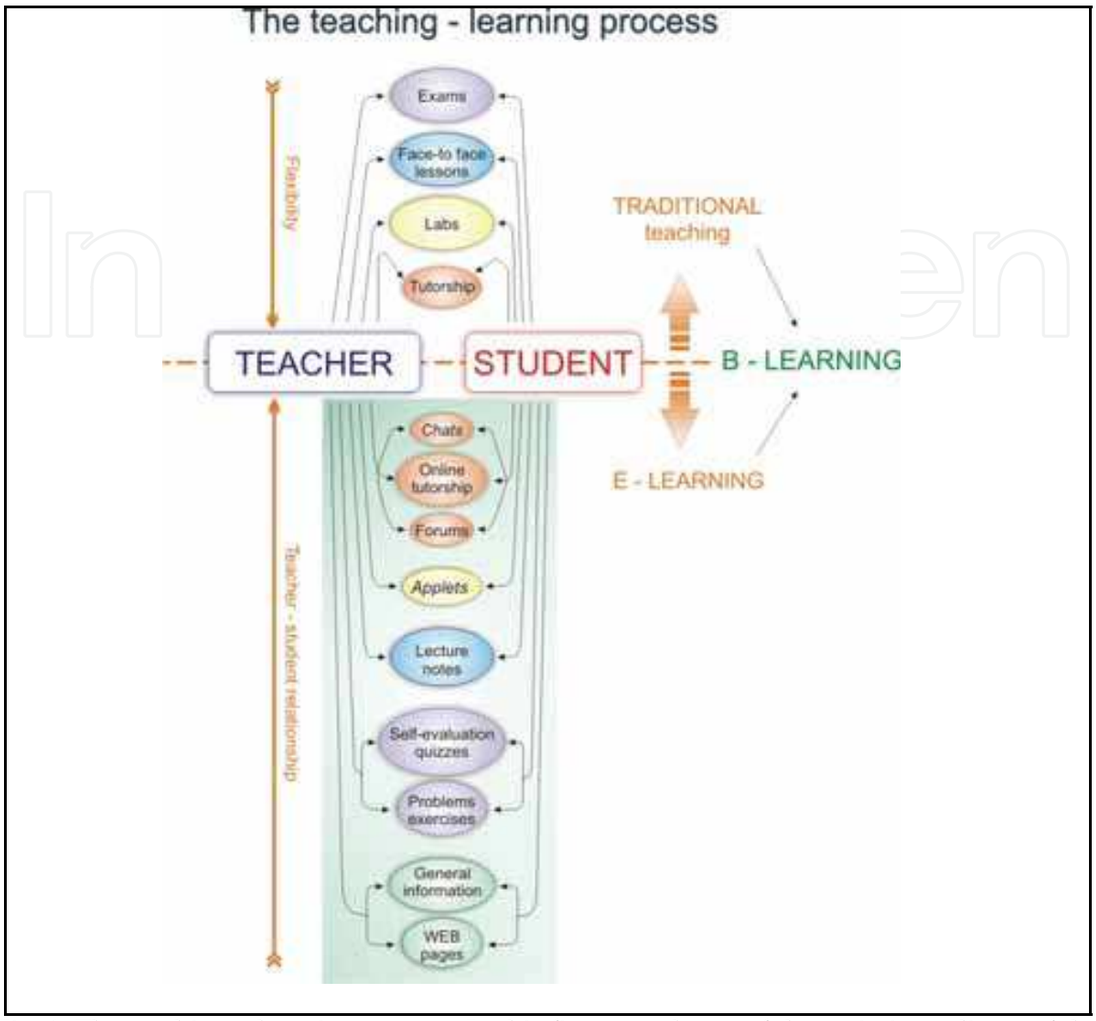


Fig. 1. The teaching – learning process. In this figure a scheme of the main ingredients of the teaching – learning process is shown. The relationship among the traditional, e – learning and b – learning methodologies is pointed out.

Examples of open-source platforms include Moodle, Ilias, Atutor and Claroline. 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.

2.2 Moodle

Moodle is a **free** and **open source** e-learning software platform created by Martin Dougiamas in 2003 as part of a research project (Winter, 2006). Since then, it has become extremely popular, having as of March, 2009, more than 29 million users in more than 2 million courses worldwide (data taken from Moodle statistics page. See Fig. 2).

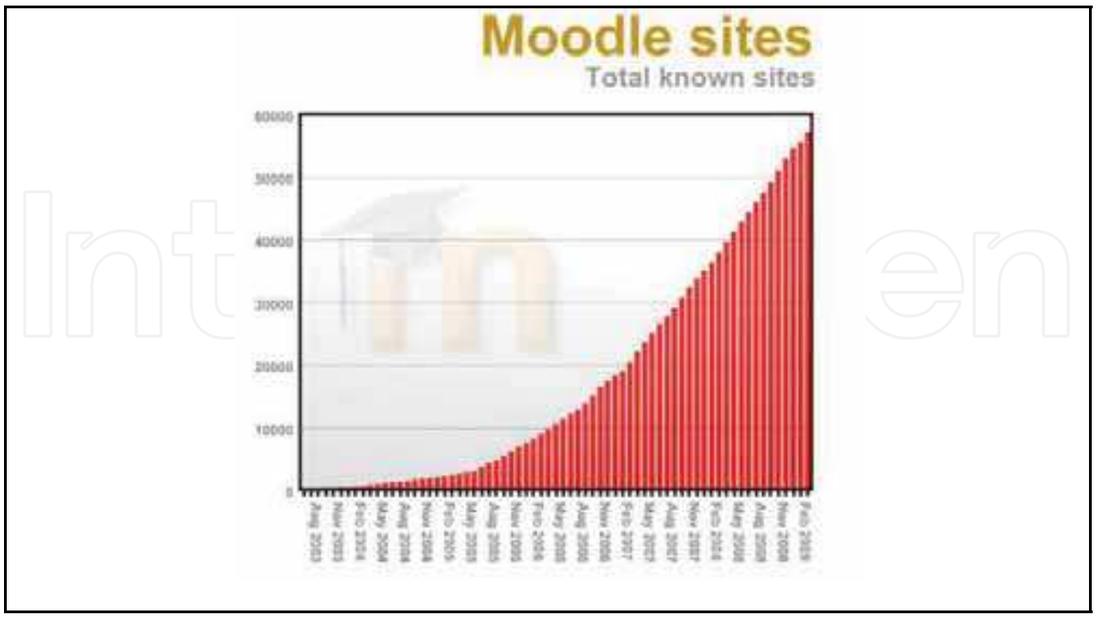


Fig. 2. Total Moodle sites from August, 2003 to February, 2009 (source: Moodle statistics page).

Moodle was originally designed to deliver online courses (that is, online learning sites), but its applications had spread to other fields; for instance, Moodle is recently being used to apply data mining techniques to the study of data coming from the educational context (Romero et al., 2008).

From the educational point of view, Moodle is a powerful tool that allows creating courses in a very easy and flexible way. Users which want to access a certain Moodle site must have an email account previously incorporated in a database, and a password. Therefore, **courses implemented in Moodle are in general accessible only to a restricted group of users**. The advantage of this feature is that Moodle courses can be used to teach as well as to give marks to different activities, in such a way that it can make unnecessary to carry out face-to face exams. Within the e-learning mode, these online courses can then be delivered remotely, with no face - to face – interaction at all.

In order to manage the different permissions for users that can access a certain course, Moodle has implemented the so - called **role assignment**. Moodle comes with seven predefined roles: administrator, course creator, teacher, non-editing teacher, student, guest and authenticated user (from build 1.8 onwards). Each role has its own permissions assigned. For example, a course creator or a teacher can edit and modify the course content. A teacher can also track the activities of the students. On the other hand, students are allowed to browse the course content and do the different activities proposed, but they cannot edit the contents or view the scores obtained by other students.

In the b-learning context, Moodle can also be seen as a platform which allows teachers proposing additional activities to those students which wish to go deeper into specific subjects and concepts developed in the classroom. It is also a very useful tool for students which want to improve their abilities on aspects such as problem-solving, reasoning, etc.

One of the main features of Moodle is its modularity, which allows uploading many **resource and question types** to help students to improve their performance.
There is a wide variety of material that can be incorporated to a Moodle course (see green-shaded part of Fig. 1). This material is organized in **blocks**, each one allowing different kind of documentation to be shown. The number of blocks is chosen by the course creator, depending on his needs. Generally speaking, the documentation in each block can be classified into two categories: **resources** and **activities**.
Resources are the contents a teacher brings into the course. If a certain Moodle course is devised as a complement to the face-to-face lessons (blended learning instruction), then these resources can include either the material used in the classroom (lecture notes, transparencies, exercises, Power Point presentations, etc.) or all sort of additional information related to the topics explained in the classroom (external links that can be opened within the Moodle page, mp3 or video files, Java applets, Flash animations, etc).

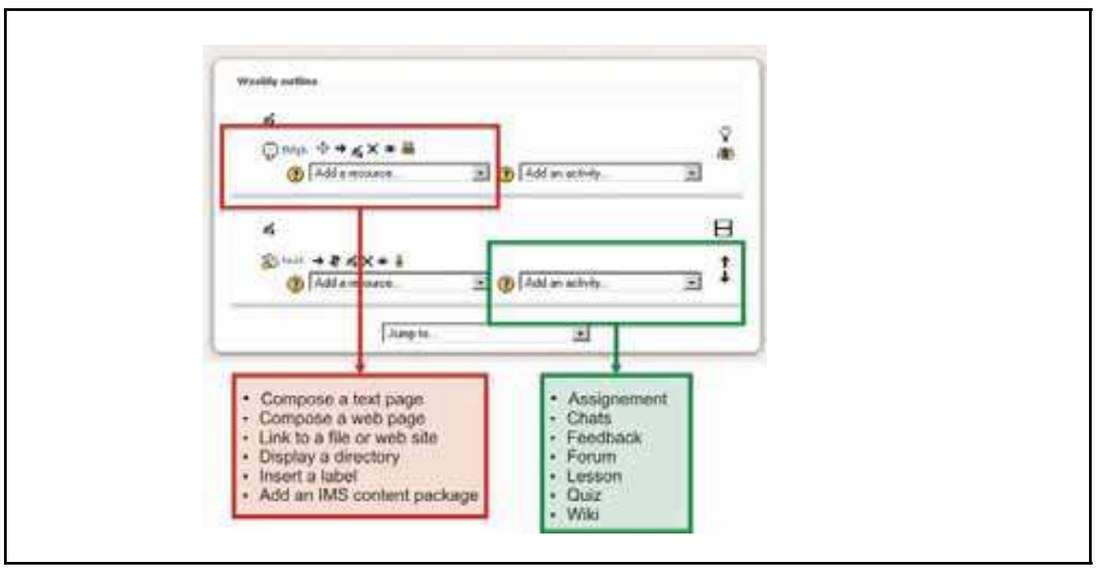


Fig. 3. Some of the resources and activities that can be incorporated in a Moodle course.

Activities are things for students to do while they are logged on to the course. These activities can include self-evaluation quizzes, tasks, exercises based on animations or computer simulations, etc. (See Fig. 3). Questions designed by the instructors are kept in a database, so they can be re-used in different quizzes. As it will be shown in Section 3, these activities have proven to be very useful for students whose aim is to improve their performance on problem-solving tasks. All modules include grading tools so teachers can assign scores to the activities based on different criteria. They also can track the students' activity as well as their performance on specific exercises with the aid of the tracking tools implemented in the platform.
Information available in a Moodle course can be retrieved both at a global level (for an entire group of users) or on an individual basis. This information can be numerical (data can be exported to a spreadsheet file for additional treatment and analysis, see Fig. 4) or graphical, since Moodle has its own plotting tools.

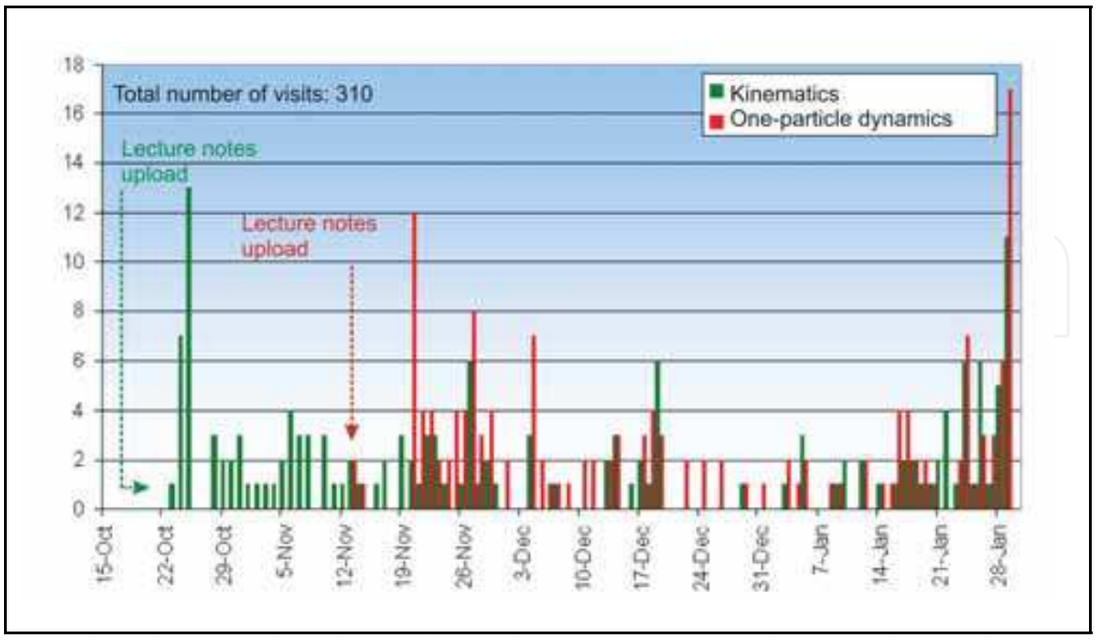


Fig. 4. Plot of the number of downloads of two resources as a function of time. Data were retrieved from the Moodle course and then analyzed with Excel.

One of the key points of Moodle is that it makes it very easy for people following a course to **interact**. **It also brings the opportunity to share information** between teachers and students and between students themselves. This fact makes the educational process a **rich and interactive experience** in which students are no longer mere spectators of the face-to-face lessons, but they can take part in their own learning process instead. For that purpose, among the activities that can be proposed in a Moodle course there are two that facilitate this interaction: **chats** and **forums**. Chats are via-web real-time synchronous discussions, whereas forums are discussion boards or threaded discussions based on problems proposed by teachers to students. They also can be discussions about specific problems that students may have found during a face-to-face lesson or while solving a proposed task or problem. Finally, Moodle brings the possibility to send **personal messages** to other users, so teachers and students can be in contact to exchange in a more personalized way impressions, difficulties and doubts.

2.3 Physics and Moodle

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 on teaching (Kenny et al., 2006). There is a wide debate about the influence of computer-assisted education in Physics courses. 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 more effective and efficient than using the traditional approach (Landau, 2006).

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. The many types of plug-ins that Moodle can manage can be used to show dynamically many physical situations and concepts that are often difficult to apprehend by the students. Computer simulations and Java applets can then be incorporated into different tasks, so learners must manipulate the relevant parameters of a given problem in order to get to its solution. This approach to a Physics problem is very useful since, as the famous quote says, *I hear and I forget, I see and I remember, I do and I understand*.

Regarding the teaching of science in general and of Physics in particular, one of the most important web-learning resources is the so - called virtual laboratory (VL), which gives students an easy way for training and learning through the Internet. Virtual laboratories are based on Java applets which have embedded simulations of Physics problems (see, for instance, (Jara et al., 2009)). Users can interact with these objects to carry out experiments. Students can navigate around the virtual world and change their viewpoints. When evaluated these systems proved to be very successful (Monahan et al., 2008). This kind of activities could be included in the so – called PBL (problem-based learning, see Fig. 5).

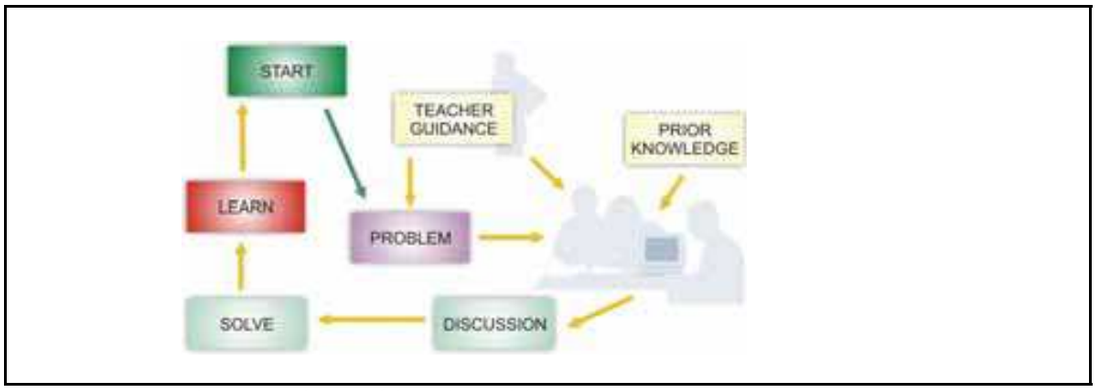


Fig. 5. Diagram showing the problem-based learning scheme.

Problem-based learning (PBL) is typically organized with small groups of learners, accompanied by an instructor. During this process, a series of problems are provided to learners with guidance early in the PBL process (with introductory problems), and then later guidance is faded as learners gain expertise, that is, when group members feel more confident with the subject matter and become more competent with the learned procedures (Merrill, 2007). Problem-based learning is often referred to as a form of Inquiry-Based Learning (IBL), which describes an environment in which learning is driven by a process of inquiry owned by the student.

Within a blended learning scheme, the online courses can be used to propose tasks involving different degrees of difficulty depending on the students' initial level of knowledge. Users of a Moodle course can be divided into groups and different tasks can be assigned to each of them. At early stages of the learning process, provided tasks can be quite straightforward to accomplish. With the aid of the tracking tools for assessing student learning implemented in Moodle, instructors can then analyze the performance and evolution of the different groups and, in accordance with the scores obtained by each one, increase the complexity of the proposed activities and resources. In this context the

instructor has also a coaching role, accomplished via the communication and interaction tools available in Moodle, the above mentioned chats, forums and personal messages.
As the scientific method is a method of inquiry that involves investigating phenomena, acquiring new knowledge, and correcting and integrating previous knowledge, problem and inquiry -based online learning strategies constitute a major advance in science teaching and learning.

2.4 E-learning platforms and open - access educational websites

Since its origins, one of the aims of the World Wide Web was to open up access to information and to break down the barriers between content creators and content consumers. As its creator Tim Berners-Lee said,

> *Inventing the World Wide Web involved my growing realization that there was a power in arranging ideas in an unconstrained, web like way.*—Tim Berners-Lee, Weaving the Web

As a vehicle to spread knowledge, there are hundreds of high quality educational websites, such as the world renowned Open Course Ware hosted by the MIT, MERLOT, PHET, etc. These sites usually provide lecture notes and multimedia contents that interactively illustrate scientific facts and phenomena. All these resources are freely accessible for everyone who has an Internet connection. Then why use the e-learning platforms?
It is arguably that, at to some extent, online courses hosted in a website whose usage is restricted to registered users limit the accessibility to knowledge since it is not available to the general public. However, in order to teach students how to create their own understanding it is often necessary to guide the students' thinking, mostly when they are following a first-year or an introductory course on a scientific topic. In that sense, e-learning platforms can also be used to organize the information available. Linking **external websites** from the Moodle course helps the students to find out where to look and how to evaluate this information. It has been shown that the use of technology improves the students' performance (Wieman, 2007).

3. An example of a Moodle Physics course

The online Physics course described below was devised as reinforcement to the face-to face lessons, that is, as a part of a **blended instruction Physics course** for first-year university (Forestry Engineering) students. Technical aspects (installation, maintenance and database management) of the Moodle platform are undertaken by the Informatics staff of the Universidad Politécnica de Madrid (UPM). Moodle is installed on a common server, in such a way that all teachers working at this university can create their own online courses and host them in the platform (see Fig. 6).



Fig. 6. UPM's Moodle homepage.

Curricular itinerary of students joining the UPM's School of Forestry spans a wide range of prior knowledge levels, so we found it necessary to figure out a way to give response to their different needs and expectations. More generally, it is a well stated fact that the university student's learning efficiencies of Physics are commonly not impressive in many countries (Redish et al., 1998). The major general reasons for finding Physics uninteresting is that it is seen as difficult and, as a result, students lose the interest to learn it. On the contrary, students joining the university with a good level in Physics could lack the needed stimulus to keep on learning if the average course level is too low for them.

Moodle's flexibility gave us the opportunity to set up a course that covered a broad scope of topics (from a basic to a more advanced level). The course was indeed student centred, that is, each student could find there exercises and activities that matched their particular needs.

Information in this course is organized in **blocks**. The **first block** is devoted to general information concerning general issues about the face - to – face course. In this block students can find lessons, labs and tutorship timetables, course syllabus and grade lists. One thing that has proven to be very useful is a section included in this block called the *course planning*, where teachers post in advance the topics that will be explained during the face – to – face lessons. Since course attendance is not mandatory, and some of the students work and study at the same time, they can follow the course even if some days they can not attend the lessons. This section is updated every two weeks, and teachers also post there the documentation that has been used in the classroom: exercises, tests, lecture notes, Power Point presentations, etc.

Within this first block there is also a section devoted to general interest links. These are links to external websites that include contents some of the students (depending on their level of background knowledge) will need: Math basics and function plotting, Physics basics and so on.

Although the Moodle platform allows including forums and chats in every block theme of an online course, we just included one general forum in the first block. This forum is devised as an online space for discussion and a real-time source of information and last-

minute news. Students can also post questions and begin a thread about doubts and concepts explained in the classroom.
The remaining blocks follow the same structure of the course syllabus. Each one is devoted to a specific topic, namely kinematics and one-particle dynamics, many-particle dynamics and rigid bodies, electrostatics, magnetism and thermodynamics. One last block has been added this year which includes activities that treat theoretical aspects needed in the lab sessions, particularly those concerned with rounding error calculations, error estimates and elementary statistical analysis of experimental data.
Each block contains different types of activities and resources. The most relevant are self evaluation quizzes, tasks based on Java applets or Flash animations, lecture notes and different kind of exercises.

3.1 Quizzes

Quizzes are a useful tool for students to test their level of knowledge. One of the hardest things about learning in a student's reference frame is figuring out what it is they don't know. This problem is particularly obvious when students face theoretical questions related to the concepts that have been previously explained during the face – to – face lessons. In order to overcome this difficulty, students need feedback about how they have done with their assignments.
Moodle provides a wide range of quiz types, all of them having in common being self-evaluative. Students then get immediate feedback when they answer a certain quiz. For this online course quizzes are of two types: true/false and multiple-choice (see Fig. 7). Apart from the questions themselves, there are many parameters that teachers can set, for instance the date at which the quiz is available, the time students have to solve it, the number of tries. Students can therefore try again when they think they have improved the knowledge they have on a specific topic. Each time the students try to solve a quiz questions appear in different order so they can't memorize the answers.

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Fig. 7. Screenshot of a multiple choice quiz from the Physics course implemented in Moodle.

3.2 Tasks based on 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.

Java applets and Flash animations are one of the most successful resources for 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 tasks 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. In order to prevent the fact that some students just watch animations as if they were watching a movie, that is, in a merely passive manner, tasks are devised in such a way that they must modify and manipulate different parameters of the physical system to answer the questions posed in the task. 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 (they can type the answer with the aid of the Moodle text editor or upload a text file), teachers receive a notification via email so they can make him some suggestions or comments about his work via the personal message utility or simply by email.

3.3 Lecture notes and exercises

One of the easiest ways to increase students learning is to upload lecture notes before the lecture. If they know in advance which topics are particularly relevant, there are more likely to pay attention to those areas, also allowing them to prepare for class. Lecture notes are regularly uploaded to the online Physics course here presented (Fig 8). As it will be shown, they have proven to be one of the most appreciated resources of the online course.

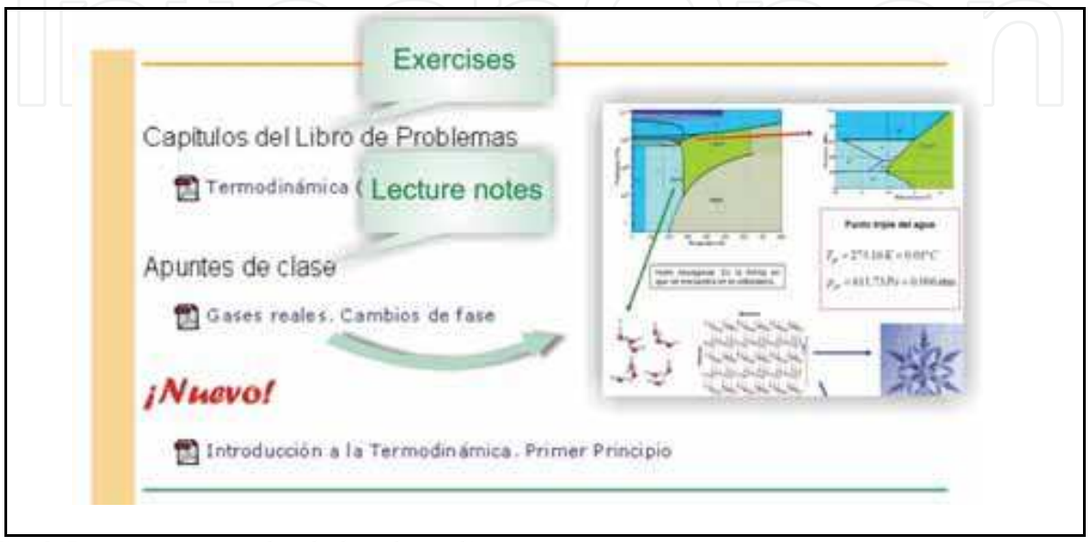


Fig. 8. Lecture notes uploaded to the online course.

Finally, collections of problems and exercises are regularly uploaded to the online Physics course. Problem solving forces the students to generate a deep understanding of concepts. These problems are usually devised as part of their home assignments, and are a very important ingredient of the student training. One interesting aspect of this activity is that students can use Moodle forums to discuss and see how others in the class have solved the same problem. Teachers can also post answers in the forum but, in that context, their role shifts from delivering information to **mentoring students**.

To end with this section, just say that a Moodle course is what teachers want it to be. Each instructor will find it more useful to include different kinds of activities, depending on the specific characteristics of the topics they are teaching, the average student level, etc. For an extensive review on how to implement different resources in a Moodle course, see (Cole & Foster, 2007).

4. Results and discussion

The blended-learning course here presented has been given for two years now. Face-to-face lectures are delivered over a period of thirty weeks (three hours per week) and cover the topics included in the syllabus. When a certain module is being delivered, the corresponding Moodle block is made available for students. All activities included in the Moodle course can be carried out by the students on a voluntary basis.

A short survey was carried out at the end of the previous academic year in order to assess the acceptance of the Moodle-based activities proposed to the students (see Fig. 9).

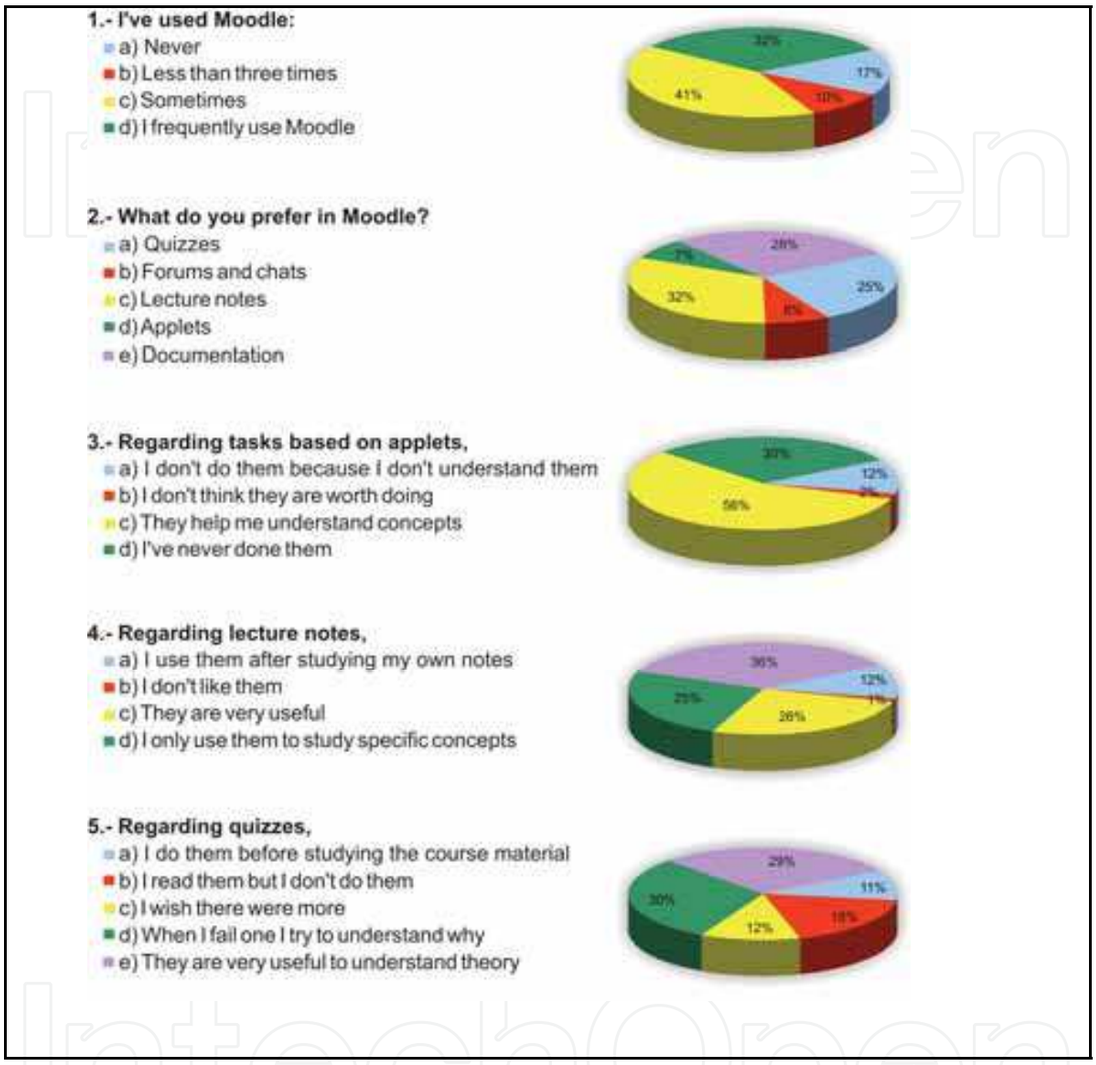


Fig. 9. Results of the survey carried out to assess the student's opinion about the online course.

A total of 71 students (all of them had followed the face-to-face course) answered the survey's five questions. These were about the different activities implemented in the online course. Students could choose more than one answer for each question.

Generally speaking, it can be seen that the perception of students of this online learning environment was very positive. From the first question it can be seen that almost 75 percent of the students used Moodle during the course, and more that 30 percent used it regularly. A majority of them considered that the most interesting resources implemented in Moodle were the lecture notes and the documentation that had previously been used in the classroom. Tasks based on Java applets were not as popular as it would have been desirable.

This result could be explained by the fact that doing these tasks requires a double effort: first, students must understand how to manipulate the simulation they are going to use; then, they have to understand the underlying physical concepts to answer the questions posed in the task. However, quizzes seem to be much more popular among them. Moreover, when students fail a quiz, they try to find out why. This is an important change of attitude, since one crucial step in the learning process in to know what we don't know. In that sense, quizzes helped the students to know their *weak points*, making possible for them to put the stress in these specific topics and concepts.

Some information about the students' acceptance of the online activities proposed in this online course has also been gathered through personal interviews. Students encouraged us to incorporate more activities to the course, demanding the same kind of tools for other subjects.

The students' performance was analyzed in depth in (Martín–Blas & Serrano-Fernández, 2009). In this reference it was shown that students that had carried out the online activities proposed during the course got better scores at the exams than the others. Maybe this was due to the fact that students that had the online feedback and guidance during the course felt more inclined to work harder than the others. It was also noted that students who were from the beginning interested in Physics took more advantage of the online tools.

5. Conclusions

In this work a review of the e-learning platforms has been done, putting the stress on the open –source Moodle platform. An example of an undergraduate online Physics course has been shown, along with the results obtained from a survey carried out among the students who followed this course.

Online platforms are a great way for teachers to organize, manage and deliver course materials both within the e-learning scheme and also for a blended instruction course. 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, improving their scores and performance.

Moodle makes it easier the interaction with the students in real-time and also allows feedback and guidance; as a learning community, this collaborative environment makes it possible for students to share their knowledge and difficulties with their instructors and with other students, so they can help each other via forums and chats.

6. Acknowledgements

This work was done in collaboration with Dr. Ana Serrano-Fernández. I must thank the Universidad Politécnica de Madrid (Spain) for providing the technical support and resources to carry out this work.

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Technology Education and Development

Edited by Aleksandar Lazinica and Carlos Calafate

ISBN 978-953-307-007-0

Hard cover, 528 pages

Publisher InTech

Published online 01, October, 2009

Published in print edition October, 2009

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!

How to reference

In order to correctly reference this scholarly work, feel free to copy and paste the following:

Teresa Martin-Blas (2009). E-learning Platforms in Physics Education, Technology Education and Development, Aleksandar Lazinica and Carlos Calafate (Ed.), ISBN: 978-953-307-007-0, InTech, Available from: http://www.intechopen.com/books/technology-education-and-development/e-learning-platforms-in-physics-education

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