

MAKING A VIRTUAL LEARNING ENVIRONMENT FOR NON-ASSISTED PHYSICS LABORATORY

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Abstract

The Physics laboratory is usually the main place where our students of engineering approach to the physical daily reality, from the technological and the scientific point of view, through experiments and motivating demonstrations.

Thinking of those students that can not follow an established schedule of attendance to the classroom, an innovative educational material has been created, which is based on digital filming of the experiments that nowadays are carried out in our real Physics laboratory. The objective is to minimize the lack of acquisition of some abilities associated with the real experimentation, by means of the use of virtual experiments and by working others individual competences by a streaming video.

The filming is accompanied by some tutorials that introduce the experiment and illustrate the associated theoretical concepts, together with some simulations. Evaluation and self-evaluation tests are also available to monitor the student's learning. Anyone can find all the material in the webpage:

<http://www.epsem.upc.edu/~practiquesfisica/>

After putting these materials into practice, we have carried out a survey in which the students compare the real and the virtual experimentation systems and to ask their opinion about the quality of the generated material for two different experiments. The answers of the students encourage us to produce more material of this kind and to improve the autonomous learning of our future students of engineering.

Workshop Topics

Autonomous learning

I INTRODUCTION

One of the paradigms of the European Higher Education Area considers students doing a lot of learning activity outside the classroom (learning languages, practising sport, part-time job, etc.). Traditional learning environment can not be as efficient as it was before with this new profile of student, if new teaching material is not elaborated, especially thinking about the autonomous learning. The digital campus has demonstrated to be an excellent tool to manage any subject, like ATENEA (a Moodle platform) at the Universitat Politècnica de Catalunya (UPC), except for experimental subjects which require manipulation of instruments; this problem is obvious for distance learning universities (UNED and UOC in Spain).

Practical work forms a key part of University level education in many subjects, engineering specially, because laboratory experimentation provides some abilities to the students that are not easy to acquire outside the lab [1].

Current and emerging trends in higher education present challenges as to how provide such practical work to the university students of tomorrow [2]:

- the increasing use of the WWW in educational delivery,
- the move towards a "flexible university" approach (in time, place and access to specialised equipment),
- the growing need to deliver life-long learning

These trends bring up two questions: (i) for our knowledge area (Physics for Engineers), which abilities does the student acquire in our laboratory?, and (ii) if he or she can not go to the attending laboratory, is there any learning model or educational material that provides the same knowledge and skills that his or her counterparts acquire in class? These questions were the origin of this work and the excuse to improve our usual learning materials [3].

Most of the known teaching material referred to virtual laboratories is not practicable within sophisticated infrastructures [4], for instance, in the case of remote control experiments, where expensive laboratory equipment is needed or can be dangerous for untrained persons (e.g. radiation measurement systems [5]).

The applications and potential benefits of the use of video in teaching and learning are well documented in the literature [6] [7]. The use of video equipment as a Physics laboratory tool is old [8] but nowadays instructors have many tools available to enhance the traditional mechanics lab [9].

There exist videos focused in the lab work which emphasize more the theoretical concepts than the applied process. The role of the laboratory work in Physics consists of studying, in quantitative details, some of the aspects of specific phenomena. Thus, not any video allows collecting data and analysing them for any unit [10]. Everybody could find commercial software to analyse simple video only from a kinematics point of view [11] [12] [13] [14] [15].

The appearance of digital video and Internet gave way to new proposals and suggestions in the learning and education field. The decrease of the cost of producing digital videos has allowed teachers recording, editing and producing their own videos, during their courses and adapted to their needs. The last technological advance in digital video is the streaming, which offers various advantages in distance education [16], such as a faster access speed compared with traditional downloaded digital video.

This situation encouraged us to generate new multimedia material, to be placed on the digital campus, according to our needs and availability. The project was financed by AGAUR (Agència de Gestió d'Ajuts Universitaris i de Recerca). We chose streaming video (see in figure 1 the schema of this system) better than podcasting, because this last one is more interesting in the work with theory or exercises but not with laboratory work [17].

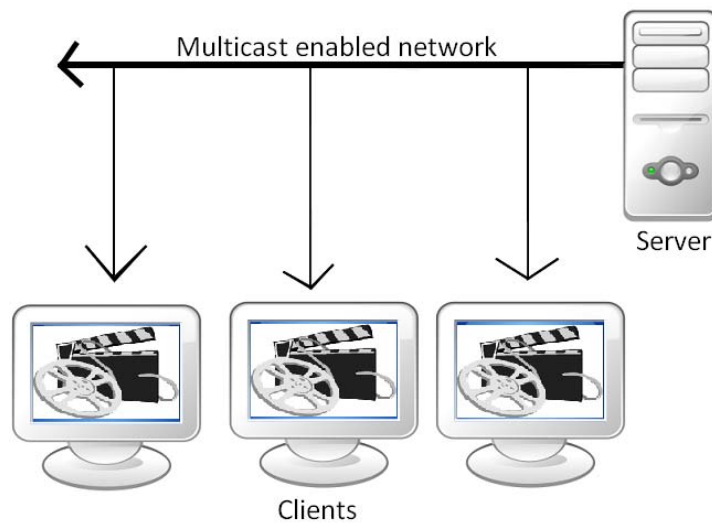


Figure 1: Streaming digital video system.

II NEW MATERIAL FOR VIRTUAL EXPERIMENTATION

To make digital filming of a high quality we took advantage of the work experience of Fundació TCM Audiovisual (a private Foundation located at Mataró, Spain). Two videos were generated in *avi* format, in 720x576 pixel window size, higher to the standard for streaming, and lastly were transformed to *flv* format and 638x480 pixel window size, in order to make less hard their visualization online. The aim has been, so, to replace handling activity by a software application, always paying special attention to measurement and quantitative data processing.

Both filming, one about inertial momentum (Mechanics) and the other one about magnetic field (Electromagnetism), are experiments that anyone can reproduce in a real way in our lab. Each video has a duration of about 42 minutes, is broken in three parts (theory, materials, measurements), and is elaborated with their corresponding screenplay oriented to make pleasant and easy the work to the student.

Each video includes the filming with which the student takes data as if he or she was in the laboratory, and also a tutorial where theory and procedure are introduced. The videos were put in the virtual learning environment and linked from the virtual campus ATENEA of the UPC, together with simulations and self-evaluation tests. Figure 2 shows some scenes of the video about the magnetic field experiment.

With all this, we want to achieve that students make measurements, draw charts, interpret and fit graphics, apply the theory of errors and uncertainties, and finally, learn how to write a scientific-technician report, without the presence of the teacher. That is, with this learning environment we try the student to be able to combine some generic competences (to adapt oneself to new situations; to handle a computer; to manage information and time; to work in an autonomous way), and some specific

competences (to understand physics phenomena; to develop experimental skills –no handle but ability to describe, to analyse and to evaluate experimental data with criticism-; to search, to work and to summarize some bibliography about Physics; to be efficient when planning their own work and to manage time and resources in a responsible way –autonomous level-).

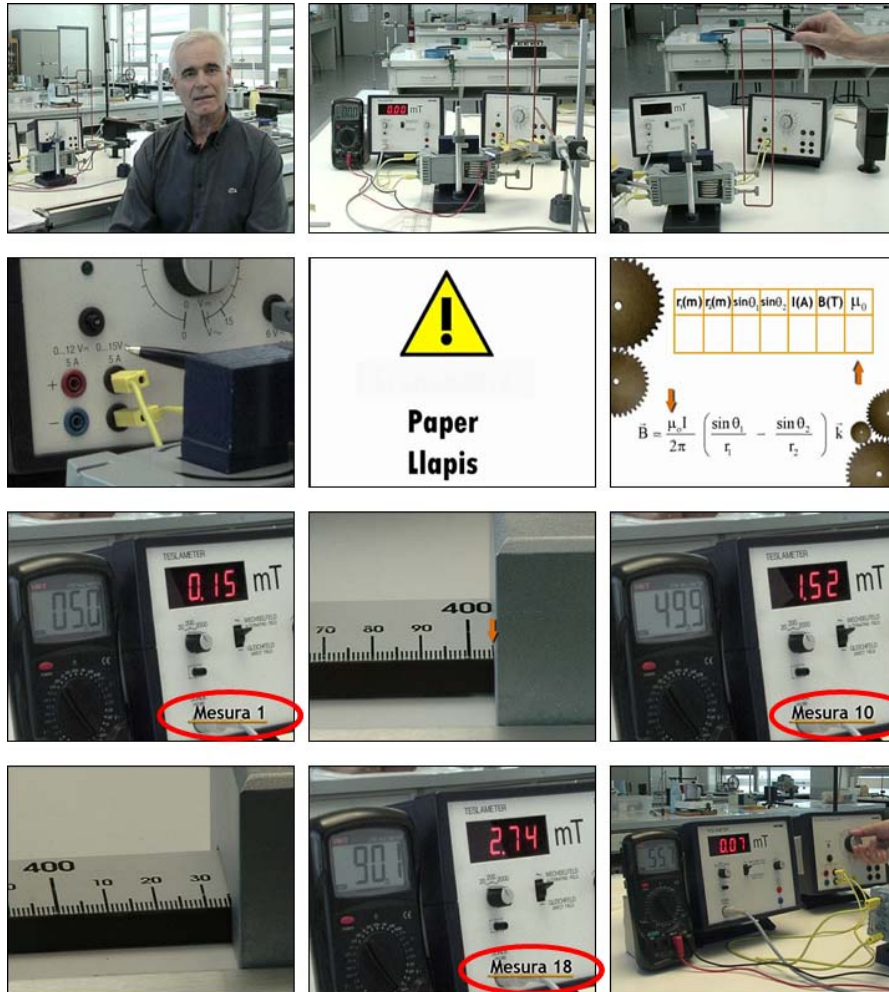


Figure 2: Some sequences of the streaming digital video about the magnetic field.

III EVALUATION OF THE VIDEO EXPERIMENTATION

As educators, we may never have an assessment tool that measures differential learning. Such a tool would, nonetheless, answer the question: “Do students actually learn more...” In the absence of such an assessment tool, we continue to rely on

indirect assessment techniques. The main tool for evaluating the usefulness of these videos was a 5-Likert scale questionnaire (SA: strongly agree, A: agree, N: neutral, D: disagree, SD: strongly disagree), which was filled out by students at the end of the course. Table 1 shows the questions of the survey.

Table 1: Questions to the students about the video-experiment system.

1. It was not easy to make the report of the experiment through the video.
2. In the real laboratory students work in pairs, and in the video lab students work alone. Working individually, in both labs, is better for the student.
3. The amount of doubts generated from the video experiment requires of the presence of the teacher.
4. The video of the lab experiment is clear enough to illustrate how to do the corresponding report.
5. Less time is needed to conduct the full experiment by the video way than if the experiment is carried out in the lab.
6. Stopping or repeating a scene of the video in order to make a measurement is an advantage, unlike the real measurement in the lab.
7. It is recommended to use the virtual lab for students which can not be present in the laboratory sessions.
8. Anyone can obtain more competences if theoretical and experimental lectures are synchronous.
9. A correct monitoring of the experiment was possible in the task of elaboration of the results.

Student survey results were mixed (N=100). When asked to consider, for instance, whether video analysis helped them understand better classroom physics lecture, 60% of the students agree/strongly agree, while only 9% of the students disagree/strongly disagree. Table 2 shows the answers to the questions of the table 1 (in %), including the evaluated feature for each question [18], a quantitative value of the response (maximum 5) and a judgment we do about each answer.

Table 2 Answers to the questions of the survey

Q	Evaluated feature	SA / A	N	D / SD	/ 5	Judgment
1	Specificity	10	35	55	2.4	☺ EXCITING
2	Preparedness	51	24	25	3.4	☹ UNEXPECTED
3	Interactivity	27	44	29	3.0	☹ EXPECTED
4	Appeal	87	10	3	4.2	☺ EXCITING
5	Efficiency	59	16	25	3.6	☺ EXCITING
6	Interactivity	95	5	0	4.7	☺ EXCITING
7	Accessibility convenience	76	14	10	4.0	☹ EXPECTED
8	Currency	42	44	14	3.3	☹ UNEXPECTED ☹ EXPECTED
9	Real time	79	21	0	3.9	☹ EXPECTED

IV ADVANTAGES, DISADVANTAGES AND OTHER CONSIDERATIONS

An analysis of the different possibilities of preparing new teaching material and the requirements of the streaming digital video system gets us to classifying different actions into advantages, disadvantages and other considerations to implement, or not, in the future. A list of them is shown here.

1. Advantages

- a. overcoming health and safety problems,
- b. access to expensive equipment,
- c. independent access to the place and instant,
- d. special attention to the needs of disabled students,
- e. access to the physics laboratory of a growing number of students,
- f. synchronous learning of theory and experimentation,
- g. all students can do simultaneously the same experiment,
- h. reduction of residuals (sustainability),
- i. possibility to combine real and virtual experimentation.

2 Disadvantages

- a. impossible to acquire the corresponding abilities of manipulation of laboratory instruments,
- b. impossibility of evaluating other aspects of the formation (e.g. work in group),
- c. minimum relationship teacher-student and student-student

3 Other aspects to consider

- a. to encourage the students to make their own videos,
- b. to use the virtual campus to evaluate the lab work,
- c. to remember that all the educational materials are complementary,
- d. to export this formative tool to other subjects,
- e. to translate to other languages,
- f. flexible curricula (the students choose the experiments to make in function of their preferences),
- g. to combine with remote experimentation,
- h. to convert the material to be used with other devices (e.g. iPod,...).

V CONCLUSIONS

We have summarized our use of video analysis with two specific case studies as well as provide mixed assessment data supporting the use of video analysis. Clearly, video analysis is not a tool to supplant each traditional lab exercise. Video analysis exercises may be best implemented in judicious doses. However, we believe that

when employed for students with difficulties to be present in the real laboratory, video analysis is useful.

Teachers showed their satisfaction after the first time of application because the average qualification was a little higher for the virtual experience than the real handle lab. Teachers appreciated also the possibility of replacing dangerous experiments (as in the magnetic field measurement) with this new material, and approved the design of the learning environment as they can try when to use the material (before, during or replacing a formal lesson). Finally, teachers had detected two conflicts, or problems, the first one is with regard to the little-enthusiastic point of view of using multimedia materials of both the students and teachers at the beginning, and the second one is due to the extra time and work deriving of this new procedure.

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