Integrating digital video resources in teaching e-learning engineering courses

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***Abstract*—In recent years, the possibilities for distance teaching in engineering education have increased tremendously. The widespread availability of the Internet has allowed the use of rich media over long distances. As visual connectivity improves, an opportunity to enrich and rethink the place of learning design in on-line and distance education is presenting itself. This paper presents a case study of development of digital video to be used in e-learning postgraduate engineering courses. Videos should be used in autonomous DVD or embedded in hypermedia learning objects. Multilingual, interactive questionnaires and mixing use of animations and real images are some features of the video. The use of these video is put to the test in a postgraduate course on Solar Energy and other Renewable Energies in Buildings**

Keywords-component; Video teaching media, solar energy, engineering education.

I. INTRODUCTION

Some studies in the field of engineering education [1], [2] point out that one of the future trends will be the greater utilization of information and communication technologies (ICT) in ways that improve teaching and learning. It is expected that such ICT will increase accessibility of students to engineering programs and allow students greater flexibility in terms of how, when and where they study. These ICT would be used in undergraduate programs as well as in postgraduate programs and engineering lifelong learning, as long as this technology can be used to accomplish pedagogical goals. The only theoretical presumption is that educational outcomes would determine the selection of teaching delivery media. That means that the introduction of the ICT must be accompanied by improvements in the understanding of learning and teaching [3], [4]. Thus, the explosion of ICT has presented teachers with the opportunity of revisit the whole question of teaching and learning and to explore new forms of deliverables that supports students' creativity.

Besides electronic books and links to technical web sites, ICT aided engineering courses frequently involves multimedia presentation with interactive exercises and questionnaires, technical video and hypermedia tools, included to promote active learning.

This paper presents a case study of development of digital video to be used in e-learning postgraduate engineering courses. Videos should be used in autonomous DVD or embedded in hypermedia learning objects. Multilingual, interactive questionnaires and mixing use of animations and real images are some features of the video. The use of these video is put to the test in a postgraduate course on Solar Energy and other Renewable Energies in Buildings, within the framework of an international e-learning project. The pilot experience was designed to answer, amongst other, the question about what would be the students' usage during the course and what would be the implications of this experience for further developments.

II. DIGITAL VIDEO IN EDUCATION

The applications and potential benefits of the use of video in teaching and learning started with the analogue videotapes in the early seventies [5, 6]. In some cases, video technology was used to improve practical teaching by developing simulated laboratory sessions [7]. In others, video-taped lectures were used in distance courses as a substitute of traditional lectures [8]. Nowadays, with the broad use of digital technology, video can be considered as a powerful medium that, first, can provide narrative visualization, and second, can engage multiple senses of learners simultaneously. Educational applications incorporating videotapes, digital video and on-line video can be found in disciplines as diverse as management, language teaching, physics and mathematical sciences, medical education and engineering.

Traditional forms of educational video include film, broadcast television and video cassette playback. Analogue video disks allowed video resources to be integrated into computer-based learning, but this technology was relatively expensive and did not become widespread. With the advent of digital video, video resources can be distributed to students via CD-ROM or DVD, on-line via the Internet, and embedded within other computer-based learning resources. Compared to traditional forms of video which are viewed primarily in a linear sequence, digital video permits more effective interactivity and control, as video elements can be quickly selected by the user, or controlled by a computer program, in any desired sequence. Although, while the technical requirements for digital video production may now be less demanding, the production of quality learning content still requires appropriate expertise [9-10].

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The first question that arises is that the role of video clips should be considered more an addition to other teaching materials than a replacement of the same. This question becomes important depending on the audience: while on-campus students are more likely to consider the video resources useful as extra information on the topic, off-campus students are more likely to consider that the video resources are useful in helping them to understand the issues involved in the topic [8, 11]. This may be due to the fact that on-campus students have easy access to lectures and academic staff, while off-campus students receive only printed or electronic study materials, and the availability of video resources may provide alternate viewpoint on the topic of study.

Another relevant question about the use of video resources is the format of the video. The format of the video can be considered in two ways: the length of the video and the recording setting. It is noted that the literature [10] recommends short video segments to maximize learners' concentration. Previous experiences reported in the literature [8] confirm this trend: it is preferable four segments video of 11-12 min duration than a video of 45 min of a full lecture. Respects the recording setting, two options are the most common for distribution: a) streaming video from a web site (for example, the university learning content management system) via broadband Internet access; and b) supply of CD-ROM or DVD version. Practical playback of the on-line video resources requires a broadband Internet connection, which on-campus students have access to in the university computer laboratories. However, due to a combination of price, technical availability and geographic factors, the uptake of home broadband Internet connections is comparatively low; hence CD-ROM or DVD would be expected as the preferred playback source for off-campus students.

When searching for video clips for teaching purposes, you can consider television broadcaster on-line resources, or websites such as YouTube, TeacherTube or BUFVC, which can be very useful. However, high level technical and/or educational videos are very scarce, and direct use of streaming videos for teaching could be inefficient for the learner if the video resource is not integrated in a comprehensive teaching approach. Further, though the use of videos is a move forward, passively observing a video is not cognitively engaging and challenging, and therefore learning is not as effective as it can be. Some interactivity should be desirable in video resources, promoting engagement and active involvement.

Most common use of integration of video resources in teaching engineering courses are related to on-campus experiences, but are very scarce when referred to e-learning, off-campus experiences. E-learning has recently become a promising alternative to the traditional classroom learning, helping society move toward a vision of lifelong and on-demand learning. Thousands of on-line courses are now being offered. Recent advances in multimedia and communication technologies have resulted in powerful learning systems with instructional video components. The emergence of non-linear, interactive digital video technology allows students to interact with instructional video. The concept is not new but is taking on new forms. However, the effect of interactive video on e-learning is still not well understood. Reference [12] describes a research mainly focused on investigating the impact of interactive video on e-learning effectiveness through an empirical study. A multimedia based e-learning system was used to teach a Management Information Systems course to freshmen, undergraduate students. Results of the experiment showed that the value of video for learning effectiveness was contingent upon the provision of interactivity. Students in the e-learning environment that provided interactive video achieved significantly better learning performance and a higher level of learner satisfaction than those in other settings.

But e-learning has also a great potential of use in life-long, postgraduate courses. It is the most frequent case for current professional engineers or architects. E-learning is partially a response to the demand for reduction in time-to-competency in the knowledge-based economy. Companies need to offer effective training to employees and business partners to ensure that they acquire new skills in a timely manner. The number of international e-courses is also increasing nowadays, due to the increase of professional mobility and the global economy. When using video resources in international courses, multilingual facilities are an added requirement for their integration in multimedia based e-learning systems. At present, none research on learning effectiveness of using video resources in teaching international, postgraduate e-learning engineering courses has been reported. This work is intended to carry out a study of the effectiveness of video resources on learning outcomes and learner satisfaction in e-learning engineering courses.

III. CASE STUDY OF INTEGRATING VIDEO IN AN E-LEARNING ENGINEERING COURSE

This paper presents a case study of development of video teaching materials for international, postgraduate engineering courses. The video will be put to the test in a postgraduate e-course entitled Solar Energy and other Renewable Energies in Buildings, within the Higher Polytechnic School of the University of Burgos. The pilot experience is designed to answer, amongst other, the question about what would be the students' usage during the course and what would be the implications of this experience for further developments.

During the period from November 2009 to March 2010, the University of Burgos will teach an international, full on-line course on Solar Energy and other Renewable Energies in Buildings, as partner of a European Union project. The project, entitled Novel and Integrated Model of Sustainable Energy Communities (NIMSEC), is focused on improving and surpassing the local level energy efficiency, and increasing the overall share of renewable energy production, especially in public buildings and/or industry and agriculture. Based on an analysis of the local framework conditions and on data collected in energy audits, concrete pilot actions are planned and implemented towards building integrated model of sustainable communities. Training courses on energy efficiency and renewable sources of energy will aim at university students on one hand and at technicians (energy auditors) and installers or distributors for renewable energy sources on the other hand.

The staff of the University of Burgos has previous experience in teaching international e-learning engineering courses, described in detail in the literature [13]. The present course will be addressed to engineers and architects who wish to become specialized in the field of the small Renewable Energy Sources applications in buildings. The learning content management system (LCMS) of the University for on-line teaching, UBUCampus-e, will be used for the delivery of the course. That implies a high grade of technical contents focused on renewable energy engineering topics. Besides electronic books and links to technical web sites, some multimedia presentation with interactive exercises and questionnaires, technical video and hypermedia tools will be included to promote active learning. In the previous experience [13], some technical or informative videos on renewable energies were included in the multimedia teaching tools. These videos, as obtained from free and public websites, were only partially related to the topics of the course, and, as a consequence, their use was considered only as complementary information on the topic. Locution was only in English language and no interactivity was allowable.

In this work, the authors have developed a pilot experience of a video on Solar Thermal Systems for Domestic Hot Water production to be used as teaching material in the next postgraduate e-learning course. When planning the teaching materials, some requirements of the video were established:

a) The video should be editted in several languages, accordingly to the international nature of the project.

b) The video should enable random access to its different parts, which is expected to increase learner engagement.

c) As a solar thermal system has no visible moving parts when fonctioning, some animations should be included to increase the visual impact of thermal concepts in the video.

d) Some kind of interactivy was desired, in conection with the learning outcomes and the assessment of the course.

e) Two versons of the video will be needed: first, one version with full facilities which will be distributed vía DVD and, second, an on-line streaming version of the video to be included in the LCMS of the University for those students with broadband Internet access.

Respect the video languages, it was decided to use only Spanish for the locution, because of the high costs of locution recording in other languages. Optional subtitles in English, French and also Spanish were then adopted as a solution to offer a multilingual video. Availability of subtitles has also a secondary benefit, thus this feature of the video increases the accessibility of the video for disabled people (deaf people).

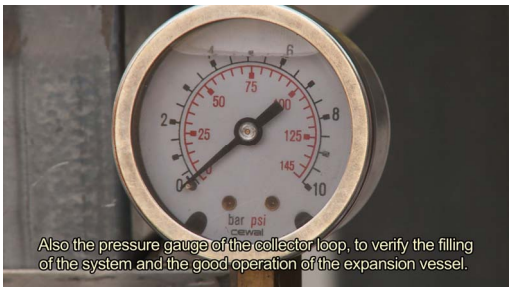
In order to provide interactive video, logic segmentation of the instructional video into seven chapters was performed. If the learner does not interact, the whole video will automatically 'flow' from beginning to end. However, the learner can perform interactive operations at any time by pressing the control buttons of the media player used, going forward or back to the next/previous unit. The user can also directly jump to any particular video chapter by clicking the correspondent sub-topic in the menu tool-bar of the media player (i.e., random access to video content). As a result, interactive video eliminates the linearity of traditional video.

2D and 3D animations have been included as a dynamic approach to some critical thermal concepts of solar thermal systems, such as the energy balance and the green-house effect of the solar collector, or the explanations about the alternate uses of the low temperature solar thermal energy systems in buildings.

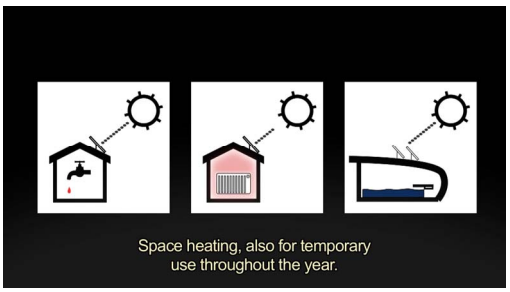
As a novelty of the instructional video, interactive questionnaires in Spanish, English or French languages are available in the main menu of the video. These questionnaires consist in multiple choice questions tests. The user clicks on the selected answer and the video offer an answer (correct or wrong) to the user. The question/answer process is visually reinforced with the change of the related picture appearing at the left side of the screen. These questionnaires are intended to be used as self-assessment exercises by the learner. The topics included in the questionnaires are related to the questionnaires and exercises that will be used in the assessment of the course.

Fig. 1 shows some examples of the features of the video described in the precedent paragraphs.

(a)



(b)



(c)

(d)

Figure 1. Examples of several features of the Solar Thermal System multilingual interactive video: (a) main manu page in Spanish language; (b) video footage with English subtitles; (c) 2D video animation with English subtitles; (d) interactive multiple choice questionnaire in French language

Recording of the video was produced in full HD quality with a camcorder. An experimental low temperature solar thermal system for on-campus teaching at the Higher Polytechnic School was used for the recordings. 2D animations were designed with After Effects CS3·software, while 3D Studio Max was used for 3D animations. Full HD plus 2D and 3D animations were integrated into video linear edition by means of Final Cut Studio2 editor.

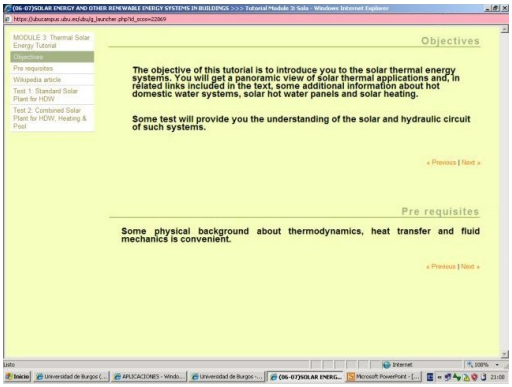
Interactive questionnaires were first edited with Photoshop to combine pictures with text-boxes including the questions. Finally, encoding of video, questionnaires and all the facilities was done with Adobe Encores CS3, which manages all the menus and options of the user.

Codification in MPEG-2 was used to produce the DVD with full facilities described, of about 1 GB in size. In this format the video can be played in any commercial DVD player or in computer.. However, for distribution through the Internet, a version with compressed codification in MPEG-4, with no optional menus and only English subtitles, was produced.

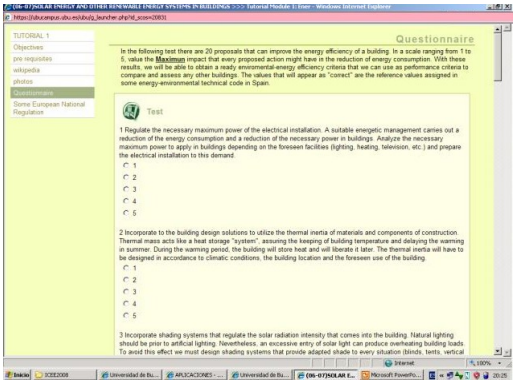
Finally, a text file in pdf format has been also included in the DVD. This text is a printed version of the script of the video, so the learner can use it as a reinforcement tool during or after the video use. The text is available in Spanish, English and French.

Author's previous experience in e-learning engineering courses [13] is that self-study materials (including self-assessment procedures) are used frequently by the students during the course and receive, in general, a very high valuation as helping tool for learning. Usually, students that achieve a higher level of mastery in the topics of the course use more frequently and during more time the self-study materials than the rest of students. At the same time, their valuation of the self-study materials is directly related to the course assessment criteria and methods, activity where they will put their extra time and effort. Therefore, we expect that the effectiveness of the proposed video resource is higher respect the use of commercial, non-interactive videos or the use of no videos.

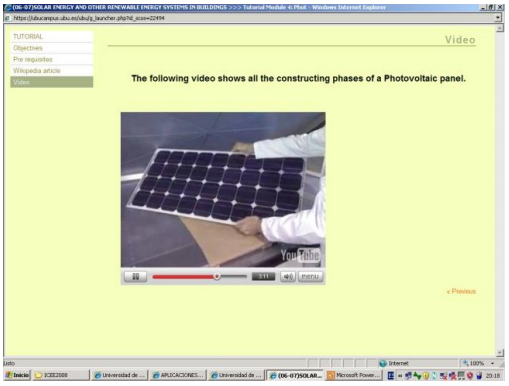
The streaming video will be included in a hypermedia tutorial conceived as a helping learning task in the corresponding module. The editor of these learning objects (exe.exe, eLearning XHTML editor) is a desktop authoring environment to assist teachers and academics in the creation of web content. The editor includes a range of pedagogical forms, e.g. objectives, advance organizers, and learning activities (text, videos, questionnaires, wikis, etc.), which constitute the equivalent of the 'teacher talk' in content resources designed for online learning. Some features of the hypermedia tutorial are presented in Fig. 2



(a)



(b)



(c)

Figure 2. Hypermedia tutorials on Renewable Energies in Buildings: (a) Objectives and pre-requisites to follow the tutorial; (b) Multiple choice test; (c) Reproduction of a linked scientific video.

The learning objective of the set of hypermedia tutorials is to broad the scope of each module and to present the information in an attractive and interactive way, in order to engage the student with the correspondent topic. Though the relevant engineering content of the course is included within

the licensed e-books (texts of reference), the hypermedia tutorials are intended to allow students to go more deeply into the specific topic.

It is expected that 25 engineers or architects coming from 5 countries of the European Union will be involved in the course. It is very probably that, for many of them, this will be the first time they will follow a full internet engineering course; also, that they probably will have to use extra time after their current job to study the course.

A survey on the effectiveness of the video as teaching material and its integration in the e-learning course will be performed. Some data about the student engagement with the video will be collected by means of a perception test. The information will be gathered by the presentation of statements to which students were invited to respond on five-point scale ranging from 'strongly agree' (5) to 'strongly disagree'(1). The questionnaire is conceived in order to elicit information about three dimensions of student's engagement with the video tutorial: learning outcomes, technical matters and easiness of use. A preliminary perception test will be posed to each student at the early beginning of the course, when he has just got an overview of the course but not still begun with the required tasks. A second test will be posed at the end of the course, when the student had finished it, in order to compare changes in the student's perception of the quality of the video tutorial, before and after using them. Scores of both pre- and post-tests will be examined through descriptive statistics. For students using the on-line streaming video distributed through the UBUCampus-e LCMS, the tracking facility of this system will be used to check every learner-content interactive operation with the interactive video

IV. CONCLUSIONS

A European postgraduate program on renewable energies in buildings, developed in an international cooperation project, is oriented to improve engineer's ability to design and construct renewable energy systems in buildings and communities, along the period 2009-2010. The international course, with a high grade of technical contents focused on renewable energy engineering topics, is addressed to engineers and architects who wish to become specialized in the field of the Renewable Energy Sources applications. The LCMS of the University of Burgos for on-line teaching, UBUCampus-e, will be used for the delivery of the course.

A multilingual, interactive video on low temperature solar energy systems, conceived as a helping learning task, has been developed by the teachers, and is included within the course contents. The learning objective of this video is to present the information in an attractive and interactive way, in order to engage the student with the correspondent topic. Being of elective use, the video include technical description of the solar system, interactive questionnaires and additional text documents for self-study, aligned with the expected outcomes and the assessment of the course. Design criteria for learning effectiveness of the video are based on literature and previous experiences of the authors.

The pilot experience will be put into force during winter 2009 and spring 2010, using the interactive video within an e-learning engineering course on renewable energies. It is expected that 25 students from several European countries will be involved. A survey will be conducted to study if the video, which provides individual control over random access to content and offer optional self-assessment of learning, may lead to better learning outcomes and higher learner satisfaction.

ACKNOWLEDGMENT

The authors thanks the Energy Intelligent – Europe program, (project NIMSEC, grant EIE/07/221 SI2.467621), for supporting this work.

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