Interactive learning objects in the delivery of e-learning engineering courses

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INTRODUCTION

In a continuous changing world, many challenges and opportunities face the engineering profession in general, and engineering education in particular. Given the multitude of ways that engineering education supports the profession, it is important that challenges and opportunities should be fully assessed and exploited beneficially where possible. Recent studies in this field [1], [2] point out that one of the future trends in engineering education 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 [3], [4]. 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 [5], [6]. Prior to introduce computer instructional technology, the idea that this technology is necessary for academic success and future employment must be revised critically. 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.

With e-learning generalization and to improve efficiency it is necessary to systematize processes and specially the creation of high quality contents by applying the learning object model [7]. Accordingly to this model contents are created by aggregation of small units that can be updated, re-used and maintained throughout the time. The educational standards try to regulate how this process is realized so that system information and the contents could be reusable, interoperable and interchangeable between learning content management systems (LCMS), which are considered 'the next wave in engineering education'. However, research into the added value for engineering education and the actual use of learning objects is scarce; as yet, we have few success stories. The added value of these current trends in engineering education needs to be evaluated to determine how this next wave of ICT in engineering education might be useful.

The basic idea is that learning objects are resources intended to be used to support learning and that they are created once and used several times. Accordingly to reference [7], reusability means sharing documents or software applications amongst teacher, altering and adapting a resource to meet the goals and purposes of the next user. Sharing learning objects have an economic advantage, as well as the opportunity of improving the quality of education, because tried and tested material will gain in quality and can be used repeatedly. Learning objects in a digital repository are accessible at any time and from anywhere in the world if one has access to the Internet.

CASE STUDY

This paper presents a case study of development of hypermedia learning objects for postgraduate engineering courses. The concept of learning object was put to the test in a postgraduate course called 'Solar Energy and other Renewable Energies in Buildings', within the High Polytechnic School of the University of Burgos. 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.

During the period from January 2006 to February 2008, the University of Burgos has taught an international, full on-line course on Solar Energy and other Renewable Energies in Buildings, as partner of an European Union project. The engineering education concerns of the project have been described in detail

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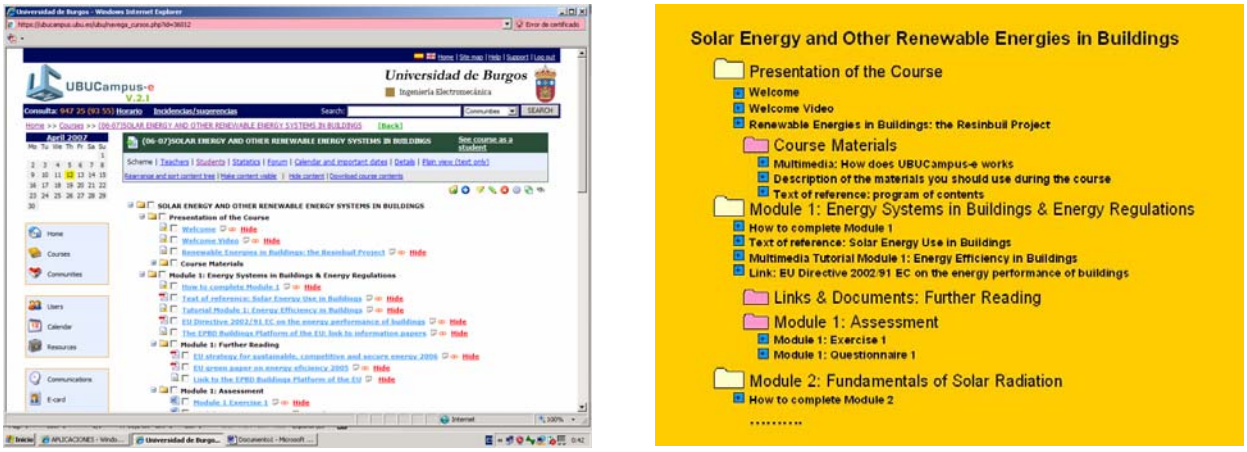
in a previous work [8]. The course was addressed to engineers and architects who wished to become specialized in the field of the small Renewable Energy Sources applications in buildings. The LCMS of the University for on-line teaching, UBUCampus-e, has been used for the delivery of the course. The UBUCampus-e is an LCMS that provides a framework for learning and teaching. The main page of the on-line course contents is shown in Fig. 1. As well as other LCMS, the UBUCampus-e system includes, amongst others, the following features:

- A repository for resources, be they documents, URLs or streamed audio and video.
- A calendar for study and assignments
- Announcements and access to the computer-mediated communication applications (public and private forum, e-mail server, etc.)
- A tracking system for completed assignments.
- An assessment and self assessment area where individual assignments are posted for students to complete or download.

The instructional materials of the course were structured into five modules: (i) Energy Systems in Buildings & Energy Regulations; (ii) Fundamentals of Solar Radiation; (iii) Solar Thermal Systems; (iv) Photovoltaic Systems and (v) Biomass and other renewable Energies in Buildings. It was expected that learners could proceed at their own pace and review as often as necessary to achieve mastery. When selecting and designing the instructional material, the main expected outcome of the course was always kept in mind, which was the ability to design and project solar energy and biomass systems for buildings. That implied 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 were included to promote active learning, following the scheme of Fig. 1.



(a) (b)

Fig. 1. Learning content management system of the University of Burgos, UBUCampus-e. (a) Main page of the course. (b) Structure of contents.

Module assessment relied on an engineering exercise and a multiple choice questionnaire. After download, solutions must be e-mailed to the Director of the course. Students received appropriate feedback and coaching by self-assessment questionnaires in hypermedia tools and Director comments to module assessment.

The hypermedia tutorials included in Modules 1 to 4, were conceived as a helping learning task in each 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 tutorials are presented in Fig. 2, 3 and 4. The design team prepared a reusable template to introduce diverse engineering concepts on renewable energies following the same logical manner and structure. Once the first tutorial was developed, it was very easy to reuse the

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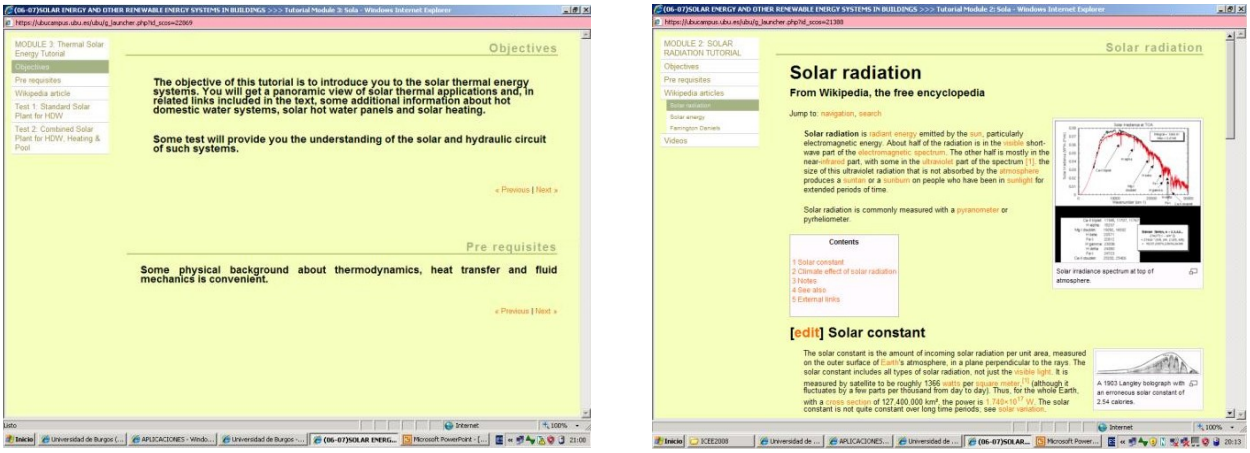
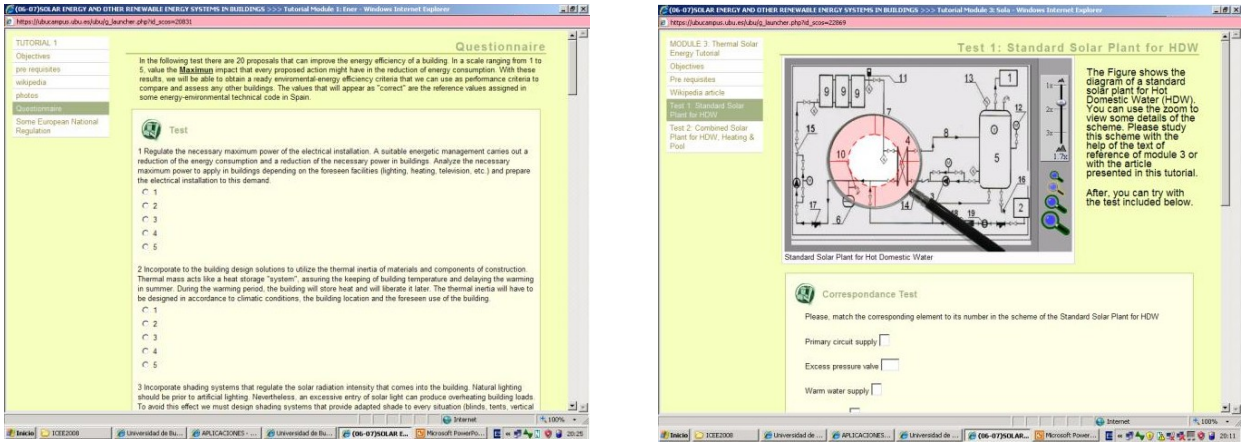
template to adapt the scientific contents and substitute the interactive tools for every Module involved in the course.



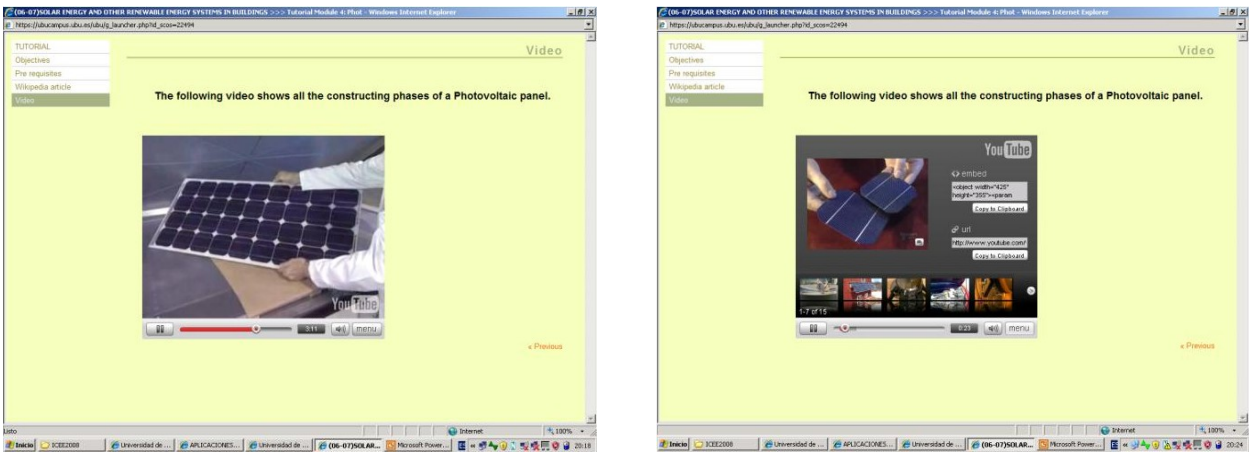
(a) **(b)**

Fig. 2. Hypermedia tutorials on Renewable Energies in Buildings. (a) Objectives and pre-requisites to follow the tutorial. (b) Link to Wikipedia scientific further reading



(a) **(b)**

Fig. 3. Hypermedia tutorials on Renewable Energies in Buildings. (a) Multiple choice test. (b) Correspondence test and visual facility for figures.



(a) **(b)**

Fig. 4. Hypermedia tutorials on Renewable Energies in Buildings. (a) Reproduction of a linked scientific video. (b) Multiple choice facility of linked videos

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The learning objective of this set of learning objects was to broad the scope of each module content 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 was included within the licensed e-book (text of reference), the hypermedia tutorials were intended to allow students to go more deeply into the specific topic. Links to very well known free Wikipedia articles on solar radiation or solar energy applications in buildings provided suitable further reading on the topic, the use of them depending on the previous background of the student. Available technical video on solar cells manufacturing or demonstrative renewable energies devices were included to foster the interest of students in renewable energy systems. Tests and quizzes were intended to promote self assessment.

RESULTS

At the end, 12 registered European engineers and architects finished the postgraduate course and obtained their diploma. For all of them, this was the fist time they followed a full internet engineering course. Also, they recognized they had to use extra time after their current job to study the course. There were two levels of mastery, depending on the assessment assignment. Every module included one or two multiple choice questionnaires (10 questions) and one open exercise related to the module content. The text of reference and, if it was the case, the available licensed software were the necessary teaching materials the student had to use to solve all the questions and problems posed. Those students that answered to the whole set of questionnaires with, at least, 50% of right answers in each one, achieved a level B of mastery on solar and renewable energies systems in buildings, the minimum level required. Those students that, in addition, solved the open exercises, achieved a higher level of mastery, level A. The subjects included in the hypermedia tutorials were not involved in the assessment, so it was possible to fulfil all the assessment requirements of the course without using the hypermedia tutorials. However, most of the students used it. Some data on the use of such tutorials have been recorded through the tracking facility of the LCMS UBUCampus-e. Table 1 presents, for each module and each level of mastery, the average number of entries and the average time of use of the respective hypermedia tutorial.

Table 1. Renewable Energies in Buildings course. Number of entries and time of use of hypermedia tutorials. Average values.

Student	Tutorial Module 1 Energy in Buildings		Tutorial Module 2 Solar Radiation		Tutorial Module 3 Solar Thermal Systems		Tutorial Module 4 Photovoltaic Systems	
	Entries	Time	Entries	Time	Entries	Time	Entries	Time
Level A	6.3	0:05:39	3.5	0:29:36	3.0	0:14:36	0.8	0:11:26
Level B	3.6	0:01:41	1.7	0:09:42	0.6	0:00:20	0.0	0:00:00

Results show a decreasing number of entries in the hypermedia tutorials along the course, in both levels of students. That means that the interest in using the hypermedia tutorials is high when the students just start the course, because of the resource novelty, and decreases at the same time they increase their interest in the assessment, for which they don't need the use of hypermedia tutorials. In relation with the time of use of the hypermedia tutorials, it also decreases along the course, with the exception of the hypermedia tutorial of Module 1. In our opinion, this is due to the level of difficulty of the subject involved. Module 1 deals with international regulations on energy in buildings, having as text of reference the European Directive on the Energy Performance of Buildings and related documents, while Modules 2 to 4 deal with the scientific and technical knowledge on solar and renewable energy in buildings. Being the hypermedia tutorials designed in the same sense, we thought that, for those who want to become qualified technicians in the field, the administrative requirements of energy systems in buildings are of less interest than those related with the design criteria and calculations methods for the same, and so is the time dedicated to them.

It is also observed that the number of entries for level A students, as well as the time of use, are always higher than those for level B, for all modules. That means a certain correlation between the level of mastery achieved and the intrinsic motivation for learning of the students, in terms of time and effort dedicated to make the most of the course. This is a very important factor for effective learning in any engineering course, but it becomes critical in full internet courses, as shown in this case.

Some data about the student engagement with the hypermedia tutorials were also collected by means of a short perception test of 3 items. The information was gathered by the presentation of statements to which students were invited to respond on five-point scale ranging from 'strongly agree' (5) to 'strongly

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disagree'(1). The questionnaire was conceived in order to elicit information about several dimensions of student's engagement with the hypermedia tutorials. A preliminary perception test was posed to each student at the early beginning of the course, when he had just got an overview of the course but not still begun with the required tasks. A second test was posed at the end of the course, when the student had finished it, in order to compare changes in the students perception of the quality of the hypermedia tutorials, before and after using them. Results are presented in Table 2.

Table 2. Renewable Energies in Buildings course. Perception test about hypermedia tutorials. Average values.

Student	(1) I think hypermedia have helped me in my learning process		(2) Hypermedia are unambiguous, they don't lead to misconceptions		(3) Hypermedia are elements of high visual and aural quality	
	Pre-Test	Post-Test	Pre-Test	Post-Test	Pre-Test	Post-Test
Level A	4.5	3.5	4.0	2.5	4.0	3.8
Level B	4.0	4.3	4.0	4.2	4.0	4.2

Student's perception of the hypermedia usefulness for learning, question 1, is very high in the pre-test (mean value 4.5 for level A students; m.v. 4.0 for level B), but decreases for level A students (m.v. 3.5) in the post-test, while level B students remain almost equal (m.v. 4.3). The same happens with the perception about the clarity of conceptions of the tutorials, question 2, where a sudden decrease from 4.0 to 2.5 takes place for level A students, while level B students remain almost unchanged (pre-test, m.v. 4.0; post-test, m.v. 4.2). An inverse correlation exists between this change and the level of mastery of the students. Taking into account that the approach taken by students to learn a particular task is an important factor in determining learning outcomes [9]-[10], it seems as if the realization of the open ended exercises, with a higher level of difficulty than the questionnaires, and the subsequent need of a deep approach to learning, lead to an underestimation of the hypermedia tutorials, which only would require a surface approach to learning. The absence of such correlation for level B students suggests also that the multiple choice questionnaires designed for assessment only would require a surface approach to learning.

About the quality of visual and aural features of hypermedia, a global high valuation is shown for both level of students, without significant changes from the pre-test to the post-test.

CONCLUSIONS

A European postgraduate program on renewable energies in buildings has been oriented to improve engineer's ability to design and construct renewable energy systems in buildings, along the period 2006-2008. The international course, with a high grade of technical contents focused on renewable energy engineering topics, was addressed to engineers and architects who wished to become specialized in the field of the small Renewable Energy Sources applications in buildings. The LCMS of the University for on-line teaching, UBUCampus-e, has been used for the delivery of the course.

A set of hypermedia tutorials, conceived as a helping learning task in each module, were developed by the teachers, and were included within the course contents. The learning objective of this set of learning objects was to broad the scope of each module content and 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 hypermedia included some interactive exercises and questionnaires, technical video and hypermedia tools, though the subjects were not involved in the assessment of the course. The design team prepared a reusable template to introduce diverse engineering concepts on renewable energies, so it was very easy to reuse the template to adapt the scientific contents and substitute the interactive tools for every Module involved in the course.

The pilot experience was designed to answer, amongst other, the question about what would be the students' usage of the hypermedia during the course and what would be the implications of this experience for further developments. Assessment about students engagement with hypermedia has been done through questionnaires and the UBUCampus-e tracking facility.

The hypermedia tutorials have been used frequently by all the students during the course and received, in general, a very high valuation as helping tool for learning. Those students with a higher level of mastery in the field of energy systems in buildings, have used more frequently and during more time the hypermedia than the rest of students. At the same time, their valuation of the hypermedia decreased along the course, because the hypermedia were not included in the course assessment, activity where they have put their extra time and effort.

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As a general conclusion, hypermedia tutorials show a high potential in e-learning engineering courses, specially for intrinsic motivated students. The effort required for developing such reusable learning objects can be reduced if a easy-of-use desktop authoring environment for the creation of web content is available. The adoption of pedagogical criteria to create the reusable template is of utmost importance. Involvement of hypermedia in the assessment criteria should be considered in order to increase their learning impact.

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