E-learning Instruction for the Implementation of a Renewable Energy Engineering Profile in an International Project

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Abstract - **One of the most important objectives of the European Union energy strategy is looking for sustainable development through the improvement of energy efficiency and the promotion of renewable energy sources. An international project focused on encouraging the use of renewable energy sources in buildings, within the Intelligent Energy Europe Programme of the European Union, is being developed by eight participants from four countries, including regional Energy Agencies, Universities and small and medium enterprises of the construction sector. The project includes training actions consisting of the development of a new profile of renewable energies technician through a postgraduate engineering programme. This international programme involves the utilization of the UBUCampus-e, a web-based environment of the University of Burgos for e-learning. The UBUCampus-e has been used in a traditional lectures postgraduate course in Spain and as a fully online e-learning environment in an international postgraduate course for European engineers. Assessment of the courses through questionnaires and the UBUCampus-e trail facility has been done. Some results related to the development of the courses and to the learning engagement are presented.**

Index Terms – e-learning, postgraduate engineering training, renewable energies in buildings, Intelligent Energy Europe Programme.

INTRODUCTION

Energy plays a large part in climate change since it is the leading source of greenhouse gas emissions. This is a relevant reason to explain why energy policy is particularly important in the European Union's sustainable development strategy. At the same time, the European Union (EU) is increasingly dependent on energy imported from third countries, creating economic, social, political and other risks for the Union. The EU therefore wishes to reduce its dependence and improve its security of supply by promoting other energy sources and cutting demand for energy. According to reference [1], the main objective of the EU energy strategy is to combat global warming, notably by promoting new renewable energy sources. Several Directives intended to promote energy efficiency and use of renewable energy sources have been already proposed in recent years [2]-[4]. The EU target is the fulfilment of 12% RES-share in the overall energy production by 2010.

As described in [2], buildings will have an impact on long-term energy consumption and new buildings should therefore meet minimum energy performance requirements tailored to the local climate. At present, 40% of the energy consumption within the EU corresponds to the residential sector, buildings being the single largest consumer. As the application of alternative energy supply is generally not explored to its full potential, the technical, environmental and economic feasibility of alternative energy supply systems should be considered. Moreover, this Directive on the energy performance of buildings estates that, for the calculation of energy performances of buildings, the positive influence of the active solar systems and other heating and electricity systems based on renewable energy sources shall be taken into account.

Within this context, the EU has launched the Intelligent Energy – Europe programme [5] for the promotion of energy efficiency and renewable energy sources. It helps all of us to produce and use energy in more intelligent ways and to increase the use of renewable energy sources.

The 'Introduction of Renewable Energy Sources in the Building sector', RESINBUIL project [6], is a granted project of the Intelligent Energy – Europe Programme. It is centred on the encouragement of the use of RES in buildings by means of a three-pronged strategy centred on new and concrete market, promotion and training actions aimed at increasing the use and installation of the small scale RES appliances, especially those powered by the solar and biomass renewable energy.

The expected overall result is a sensible increase of the use of the small scale RES applications at the local level and especially in the thermal solar, photovoltaic and biomass RES sector. This international project, with eight partners from four countries, includes local or regional Energy Agencies, Universities, installers and manufacturers of the RES small scale appliances and Small and Medium Enterprises (SME) innovation centres. Table 1 presents a full description of the partners.

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TABLE 1
PARTNERS OF THE RESINBUIL PROJECT

Energy Agencies
(Coordinator) Agencia Provincial de la Energía de Burgos AGENBUR Burgos (Spain)
Razvojna agencija Sinergija SINERGIJA Moravske Toplice (Slovenia)
Agenzia Provinciale per l'Energia e L'ambiente di Trapani Srl APEA-TRAPANI Trapani (Italy)
Harghita Energy Management Public Service HARGHITA Miercurea Ciuc (Romania)
University
UNIVERSITY OF BURGOS Department of Electromechanical Engineering Burgos (Spain)
RES Installers
Integral de Sistemas Energéticos del Norte, S.L ABASOL Burgos (Spain)
Re-Ing, Brdnik Jože s.p. REING Murska Sobota (Slovenia)
SME innovation centre
Centro Europeo de Empresas e Innovación-Burgos CEEI Burgos (Spain)

During the previous study carried out to elaborate the project proposal, one of the most important barriers detected in using RES is the need of an adequate training of the engineers and technicians usually involved in the heating, cooling and electricity supply projects in buildings. So, the principal involvement of the University has been the creation of a RES technician profile, acting as a support measure for the RES expansion in energy supply outlook. The University exact role has been the development of national and international postgraduate engineering courses on RES in buildings through.

THE RENEWABLE ENERGY SOURCES ENGINEERING & TECHNICIAN TRAINING PROGRAM

The University of Burgos has prepared the training material and has organised two different courses, an attendance course for Spanish participants and an on-line course for foreign participants. The same will directly educate and train small groups of students preparing them to become skilled RES technicians. The two different courses have slightly different material. The attendance course has been a higher level course for those, for an example, with an engineering degree who wished to become specialized in the field of the small RES applications and RES in general. The on-line course, however, has been a far more basic course for those wishing to become fully trained technicians in the same. The expected outcomes are that the attendants, at the end of the respective course, would be able to:

- Understand the main role that the renewable energy sources play in the present energy context.
- Design and project solar energy and biomass systems for buildings

The high level attendance RES course has already been carried out at the University of Burgos during Autumn 2005/Winter&Spring 2006, and has had the associated degree of complexity, the full duration of the course being around 200 hours. The teaching methodology has followed an instructional approach, focused on targeted information (lectures, laboratory, RES engineering handbooks and software) through a guided delivery to the learner. The learning process has included four phases: (1) presenting the information, (2) guiding the learner, (3) practising and (4) assessing the learning. These four phases have been used by most of the teachers through a face-to-face delivery. Accordingly with the outcomes mentioned above, the assessment of the course relied on the realization of the final project, which has shown if the attendants have become skilled RES technicians. As a complement, the web-based environment of the University for on-line teaching, Ubucampus-e, has been used. This environment is a recent development of the University of Burgos, with the majority of the common facilities of e-learning environments, and is intended to complement the traditional teaching (lectures, laboratory work, etc.) in graduate and postgraduate programs. The main page of the Spanish course contents of this web-based learning tool is shown in Figure 1.

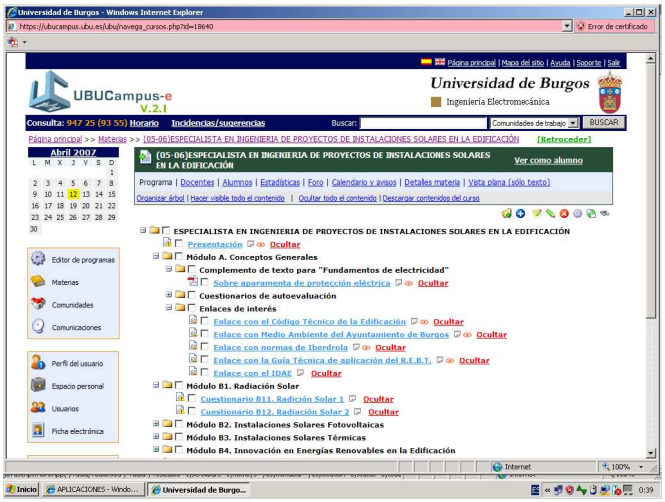

FIGURE 1
HIGH LEVEL SPANISH ATTENDANCE RES IN BUILDINGS COURSE. WEB-BASED LEARNING ENVIRONMENT OF THE UNIVERSITY OF BURGOS, UBUCAMPUS-e.

The international on-line RES course has started in January 2007 and will be open till September 2007, with an expected student workload of 100 hours. The course is fully delivered by UBUCampus-e and the teaching methodology has followed an instructional approach as well, although the teaching materials are different (electronic books, hypermedia tutorials, video presentations, engineering software). The assessment rely on questionnaires and exercises in each module and on the realization of the final project. The main page of the on-line course contents is shown in Figure 2 (English version). The documents and menus are in English, but the assessment questionnaires and exercises are also available in Italian, Slovenian and Romanian, because of the great number of attendants from

these countries (due to the advertising tasks developed by the partners of the project).

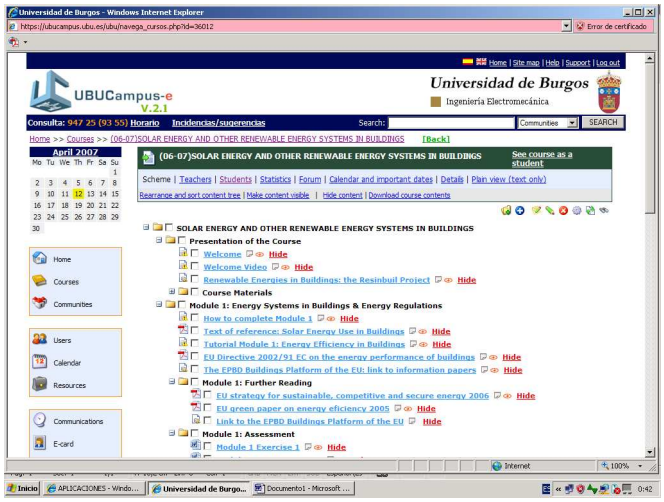

FIGURE 2
HIGH LEVEL INTERNATIONAL ON-LINE RES IN BUILDINGS COURSE. WEB-BASED LEARNING ENVIRONMENT OF THE UNIVERSITY OF BURGOS, UBUCAMPUS-e (ENGLISH VERSION)

The programme of contents and student workload of both courses are described in Table 2.

TABLE 2
RES IN BUILDINGS COURSE. PROGRAMME OF CONTENTS AND WORKLOAD

Module Contents	**Attendance Course** Hours	**OnLine Course** Hours
A General Concepts in RES International, national and regional context of RES. Technical Codes in Buildings: Energy Requirements. Local or regional RES legal ordinances.	35	12
B Solar Radiation and Energy Fundamentals.	10	10
C Photovoltaic Solar Systems in Buildings. Fundamentals, elements , calculation and design of Photovoltaic Solar Systems. Type of Projects of Photovoltaic Solar Systems	40	20
D Thermal Solar Systems in Buildings. Fundamentals, elements , calculation and design of Thermal Solar Systems. Type of Projects of Thermal Solar Systems	40	20
E Other RES in Buildings Biomass in Buildings. Research and Innovation in RES in Buildings	10	8
F Final Project	65	30
Total	200	100

As mentioned above, the attendance course workload involves 200 hours. A high percentage of them are traditional lectures and exercises guided by the teachers (above all those belonging to Modules A to E) while the rest are dedicated to an essentially active learning task proposed through the design of a renewable energy system for a building in the final project (Module F). The involvement of a relevant amount of the course workload on the final project and the placement of the assessment on this task are oriented to reach the expected learning outcomes of the course, and are coherent with the professional work of engineers and architects.

Otherwise, the 100 hours of expected workload involved in the full on-line course are of personal, active student learning, because of the intrinsic teaching-learning process. Each module has its own assessment through a questionnaire and an exercise, which serves as milestones and for feedback of the students before they take up with the final project.

THE E-LEARNING INSTRUCTION

At present, higher education institutions are broadly involved in the adoption of information and communication technologies (ICT) in the hope of efficiency gains [7]-[10]. 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.

The UBUCampus-e is an ICT organizing system that provides a framework for learning and teaching, commonly referred to as virtual learning environments (VLE) within the literature. As well as other VLE, 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 features and facilities of the UBUCampus-e system can be tailored to the requirements of individual courses. In the case of the high level attendance postgraduate course on RES, a blended teaching methodology that combines the synchronous learning of traditional lectures with the asynchronous learning through the VLE system has been used. This blended methodology is clearly shifted to the former one because of the prevailing role of the face-to-face delivery during the course (seven contact hours per week, on Thursday and Friday, along seven months, and the assessment through the final project). The e-learning activities proposed have had only a complementary role. UBUCampus-e system has been used to delivery self-assessment questionnaires in each module, documents and notices of interest, useful links and e-mail correspondence. Some comments about student's engagement with e-learning could be made thanks to data stored in the tracking system. A 100% of the 28 attendants used at any time the VLE, but in quite different ways and styles. In relation with the most interactive activity proposed to the students, the self-assessment questionnaires, they were intended to serve as intermediate challenging opportunities to receive a feedback of their progress in the course. As the fulfillment of the questionnaires was a willing task, the students were stress-free of grading but, in the opposite, their engagement in the task depended very much on their intrinsic motivation. Twelve questionnaires corresponding to the several modules (Module A: questionnaires 1 to 5; Module B: 6-7; Module C:

8-9; Module D: 10 to 12) were used. Each one of them consist of 10 multiple choice questions related to the materials delivered both through the lectures and the repository of documents of UBUCampus-e. The questionnaires only could be completed on line and only registered data of users with a recorded time higher than 2 minutes in each questionnaire are considered, which excludes ineffective 'see and exit' entries. Figure 3 shows the total percentage of users of each questionnaire and the percentage of users that have effectively completed the same with good mark (over than 50% of correct answers). Both graphics show a decreasing use of the questionnaires along the course, being less used when the final project activity came close. It also shows that questionnaires related to Module A (international, national and local context of energy in buildings) are the ones of higher general interest. Between the options of solar energy, the questionnaires of photovoltaic systems (Module C) had awaken less interest than those related with thermal systems, probably due to the respective professional profile of the attendants.

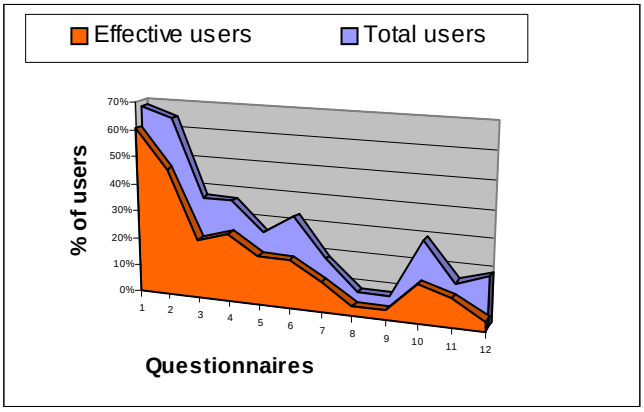

FIGURE 3
HIGH LEVEL SPANISH ATTENDANCE RES IN BUILDINGS COURSE.
PERCENTAGE OF USE, SELF-ASSESSMENT QUESTIONNAIRES, UBUCAMPUS-e

In relation to individuals, Table 3 shows the total number of questionnaires fulfilled by each student. Results are presented by intervals of three questionnaires each. It is remarkable that, on the one hand, 5 students (18%) never used the questionnaires while, on the other hand, only 1 student completed the 12 questionnaires obtaining, furthermore, a quite good mark (an average upper than 73% of correct answers). Also, a strong correlation has been found between the total number of questionnaires used by each attendant and its professional career. The attendants working in architectural or energy engineering firms have been the most engaged with the questionnaires, in contrast with the rest of the students with other jobs. The most reasonably explanation is that the formers had a deeper intrinsic motivation because the course deals with a subject that is interesting to improve their professional career.

TABLE 3
HIGH LEVEL SPANISH ATTENDANCE RES IN BUILDINGS COURSE.
TOTAL NUMBER OF QUESTIONNAIRES FULFILLED BY EACH STUDENT.

Total Number of questionnaires fulfilled	0	1 to 3	4 to 6	7 to 9	10 to 12
Number of students	5	11	7	3	2
Percentage of students	18%	39%	25%	11%	7%

The frequency of use of other instructional materials (documents, news, useful links) shows a very similar profile than the one sketched in Figure 3 for the questionnaires. Feedback and coaching for the e-learning activities were not provided, because of the prevalence of lectures.

The second challenge of the project is the development of an e-learning postgraduate program on RES that should be taught to engineers and architects from European countries. The course is being delivered through UBUCampus-e and the instructional materials are structured in the modules outlined in Table 2, so the learners can 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 has been always kept in mind, which is the ability to design and project solar energy and biomass systems for buildings. 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 are included to promote active learning following the scheme of Figure 4.

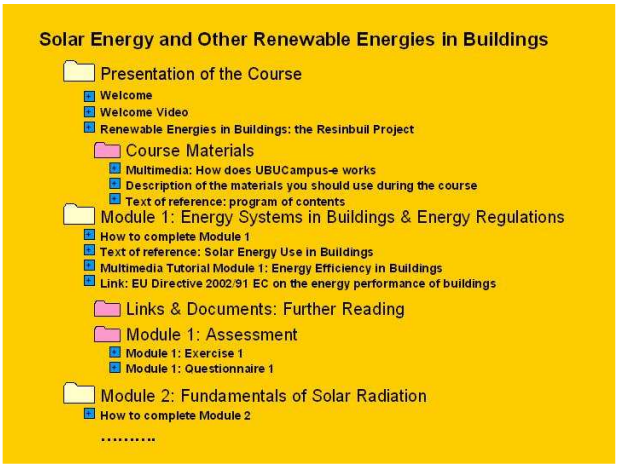

FIGURE 4
HIGH LEVEL INTERNATIONAL ON-LINE RES IN BUILDINGS COURSE.
STRUCTURE OF CONTENTS, UBUCAMPUS-e

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

At present, 28 European students registered are in progress, and some preliminary data about their engagement with the e-learning course has been collected by means of a test of 11 items. The information was gathered by the presentation of statements to which students were invited to respond on five-point scales ranging from 'strongly agree' (5) to 'strongly disagree'(1). Statistical significance of results were analyzed by descriptive parameters as mean value and standard deviation. The questionnaire was conceived in order to elicit information about several dimensions of student's engagement with the e-learning (Table 4).

TABLE 4
HIGH LEVEL INTERNATIONAL ON-LINE RES IN BUILDINGS COURSE. STUDENT'S RESPONSE (MEAN VALUE AND STANDARD DEVIATION) TO 11 MAPPED STATEMENTS PRESENTED RELATING TO THEIR ENGAGEMENT IN E-LEARNING.

Statement	Mean Value	Std. Dev.
1. Through my Internet connection, the UBUCampus-e menus and screens display at a reasonable speed	4.0	0.45
2. Software crashes occur very rarely	3.9	0.70
3. All the multimedia function correctly in my computer	3.6	0.67
4. Learning objectives and goals of the course are clearly stated from the beginning	4.4	0.67
5. I think I am actively involved in the learning process	4.3	0.65
6. I think I learn in my own pace	4.3	0.79
7. The structure of the course allows me to decide what to learn and in what order to learn	3.8	0.75
8. I think the course is very interactive	3.9	0.70
9. Instructions clearly explains how each module is to be completed	4.4	0.67
10. I think this course will offer some opportunities of getting more information that the merely presented in it	4.5	0.69
11. I think full internet courses are as good as attendance courses to learn engineering issues	4.0	0.77

Questions 1 to 3 address the availability and usability of internet technology, a previous aspect of main importance in such course. The students perception shows a good agreement with the reliability of the Internet connection, (question 1, mean value 4.0), and the software runs usually without problems (question 2, m.v. 3.9). In relation with the question if multimedia functions correctly, agreement receives a lower valuation (question 3, m.v. 3.6), and some troubles with file icons appearance depending on the internet navigator have been pointed out.

The e-learning instructional design is another essential component of learning. Questions addressed to this issue shows a good general valuation. The learners are aware of learning objectives as they are using the virtual learning environment (question 4, m.v. 4.4), and they feel actively involved in the learning process (question 5, m.v. 4.3), which is coherent with its decision to register in the course. The students feel very comfortable learning at its own pace (question 6, m.v. 4.3) but not so much deciding in what order to learn (question 7, m.v. 3.8). It is very plausible that, while the course is available at any time, the sequential presentation of some of the scientific content of the modules limit in what order the modules could be completed. The tasks to complete each module are clearly stated (question 9, m.v. 4.4) and the perceived interactivity of the course (question 8, m.v. 3.9) reflects that the choices that students make are meaningful and not just not for the sake of making choices.

Last two questions address relevant features in e-learning engagement. The first one is that the registered engineers and architects believe that the course offer them some opportunities of getting more information than the available instructional materials, which receive the highest punctuation (question 10, m.v. 4.5). They recognize the added value that means the possibility of keeping in contact with other engineers and architects with the same concerns, and with the Energy Agencies and other partners of the countries participating in the project. The second question is that, even though this is the first full on line course for all the students, their perception about the potential of internet systems to learn engineering topics is quite good (question 11, m.v. 4.0). This attitude is also an encouraging factor for e-learning engagement.

CONCLUSIONS

The development of an international engineering and technician training program in RES is a relevant novelty of the RESINBUIL project. The postgraduate program on renewable energies in buildings has been oriented to improve engineer's ability to design and construct renewable energies systems in buildings, due to the scarce number of RES skilled engineers in the participant countries of the project.

This international program involves the utilization of the UBUCampus-e, a web-based environment of the University of Burgos for e-learning. The UBUCampus-e has been used in a traditional lectures postgraduate course in Spain and as a fully online e-learning environment in an international postgraduate course for European engineers.

Assessment about students engagement with e-learning has been done through questionnaires and the UBUCampus-e tracking facility.

In the case of the blended lectures-VLE course, the face-to face delivery due to lectures and the final project have had a prevailing role over the e-learning tasks. Engagement with e-learning in the blended postgraduate course seems to have been effective only for very self-motivated students. Furthermore, absence of feedback and coaching through VLE has lead students to an underestimation of the e-learning tool. When using e-learning in blended lectures-VLE courses, enough attention to this aspect must be paid by the e-learning coordinator and teachers. Even some grading concerning e-learning activities are suggested.

On the other side, student engagement in full online courses is of utmost importance. The challenge is the development of interactive learning exercises related to the learner's experience level. The materials should be structured so the students proceed at their own pace and receive appropriate feedback and coaching. Although most students are skilled in the use of computers, even minor technical problems are sufficiently frustrating.

Effective learning depends very much on instructional design of materials. A great effort in providing the student prior information about the intended learning objectives must be done. If this aspect is not sufficiently considered, the student feels confused. Postgraduate students could have broad differences in background knowledge and experience, ability and interests, but they are usually very interested in improving its personal training and professional career. As so much motivated students they usually appreciate some VLE e-learning opportunities such as flexible long-life learning and the opportunity to keep in contact with other professional and colleagues.

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