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TECHNOLOGY ENHANCED ENGINEERING EDUCATION IN CONTEXT OF CRUNT TEMPUS EUROPEAN UNION PROJECT

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Abstract. *In the CRUNT TEMPUS project, e-pedagogy of using ITC learning environments was used. Elearning inter-university network of Moldova uses a virtual learning environment for training and learning process improvement dedicated to engineering students. The article presents some methodological elements that contributed to the success of TEMPUS CRUNT Project. Several web courses, based on Blended Learning methodology are highlighted.*

This paper presents elearning instruction materials for engineering undergraduates developed on the Virtual Learning Environment http://elearning.utm.md/moodle/login/index.php/. Electrical Engineering and Technology (EET) Discipline model is a new approach to learning electrical technology-one that presents concepts in the customary logically developed order but illustrates them with exemplars that reflect the applications students are interested in. Electrical Engineering Discipline resources are especially for secondary school teachers and students, with topics ranging from introductory to advanced Electrical Engineering and Technology.

Teachers will find reliable and quality resources including videos, articles, demonstrations, worksheets, assessments and activities all in one location. Resources are searchable by topic and standards. eLearning Modules are using visualization of electrical engineering concepts.

Keywords: powers in nonsinusoidal situations, measurement of electric power quantities under sinusoidal, nonsinusoidal, balanced, or unbalanced conditions, harmonic pollution of power systems

1. Introduction

Teaching Engineering as one of the components in the foundation technological program has been a challenging task to electrical engineering lecturers. A course webpage was constructed with the Moodle software system that utilizes various applications such as forum discussions, on-line assessments, accessing course information and learning resources including videos and useful

links. The web application is not a duplicate of classroom content but serves as a complementary to further provide guidance and assistance to students' learning outside the classroom. Therefore, the research will investigates students' perception on the usefulness of the course webpage in terms of content, accessibility, satisfaction and whether the experience stimulated their interest towards learning Engineering. The hybrid approaches offer flexibility and provide adequate support to students in learning EET.

The principles of ICT integration in engineering education are expressed as seven specific learning objectives for Teaching Engineering by using Blended Learning:

1. Critically apply the pedagogical principles of ICT integration in education.
2. Develop and facilitate ICT-based learning activities in the context of teaching EET.
3. Analyse and evaluate appropriate content and context for the use of ICT in EET teaching.
4. Use appropriate and varied communication and multimedia tools (emails, websites etc) in teaching and learning EET.
5. Use ICT efficiently in research, problem solving and project-based learning in EET.
6. Use ICT efficiently for professional development in the context of teaching and learning EET.
7. Integrate ICT appropriately into EET curriculum activities that will foster students ownership of their ICT-rich learning environment.

Methodology. Electrical Technology courses in higher education have traditionally been composed of lectures, problem-solving sessions, and laboratories. This study was aimed at developing a freshmen Web-based EET course and investigating the performance of the students who use it. The course Web site included the following elements:

- Weekly problem sets, for which solutions were provided a week later
- Hyperlinks to Web sites that provide information about topics in EET that are relevant to the course, including historical and philosophical background
- Hyperlinks to sites that provide access to free computerized electrical circuits and drives modeling software
- An electronic forum that enables students to pose questions and instructors to answer them

An optional, individual CMM project. The Capability Maturity Model project was originally developed as a tool for objectively assessing the ability of government contractors' *processes* to implement a contracted software project.

2. Using the moodle platform in class

Moodle is a tool which enables teachers to create a website environment for your class with online activities such as forums and quizzes.

"Moodle is a Course Management System (CMS), also known as a Learning Management System (LMS) or a Virtual Learning Environment

(VLE). It is a free web application that educators can use to create effective online learning sites." (http://moodle.org/)

Course Webpage Design and Description by using Moodle platform (VLE, Virtual Learning Environment)

The blended learning environment was designed for a course entitled "Electrical Engineering and Technology, EET", which was a core module offered to engineering students. The front webpage provides the overall course content of the EET module with the names of the chapters, followed by the activities in a drop-down list for each chapter. The activities involved in each chapter include: course materials, additional materials, quizzes, open forum/chat and latest news message/calendar.

Fig. 1. Blended Learning course developed at the Technical University of Moldova, Chisinău, Republic of Moldova

Course materials. There are a total of nine chapters in EET with topics of namely, …. Each of these chapters has plenty of information and activities related to the topic. This includes the course materials in the form of PowerPoint slides and Acrobat PDF documents, which are the duplicates of hand-outs that the students received in class. It is important to provide a softcopy to the students, as it is colored compared to their hardcopy and helps better in comprehending complex diagrams or figures.

Additional Materials. Nowadays students are very much visual learners. The majority of the students expressed the strongest preference to visual learning style compared to other learning style dimensions. This implies that engineering students are strongly depending on visual learning environment. Video is clearly a valuable additional learning activity that provides a sensory experience that allows concepts and ideas to actually become alive and connected. It has the option to rewind and review a particular section of the video to ensure students understand the key concept.

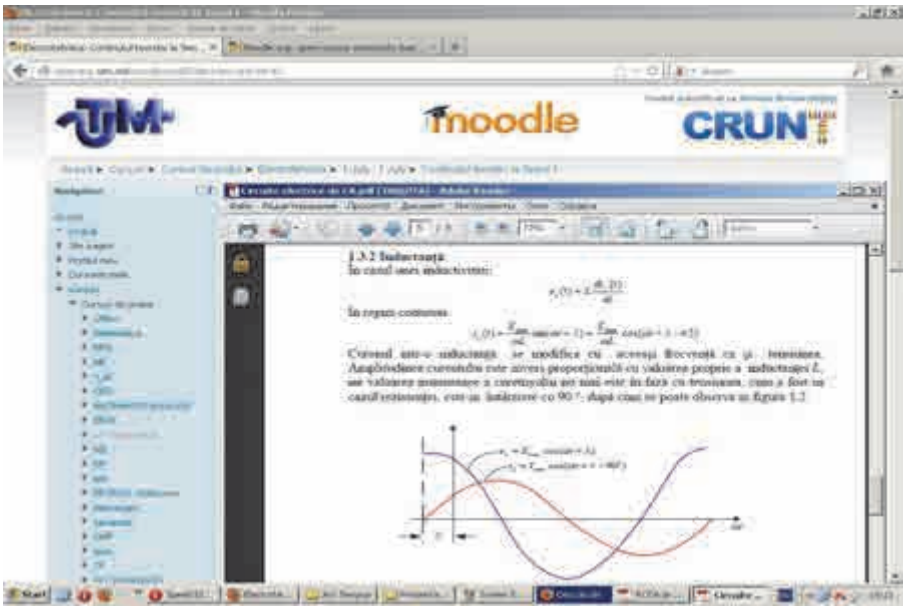

Fig. 2. The Content Presentation of "Electric Drive and Automation of Industrial Mechanisms"

Thus, free educational video sharing websites that explained the EET theories were uploaded in the webpage. In addition to this were video links from You Tube. Apart from this, problems and solutions as well as simplified diagrams explaining complex concepts, taken from textbooks or take-home questions which were not discussed in class, were made available online for students. In each of these adapted materials, references were stated clearly in order to allow students to seek the original sources if the need arises, apart from avoiding copyright infringement.

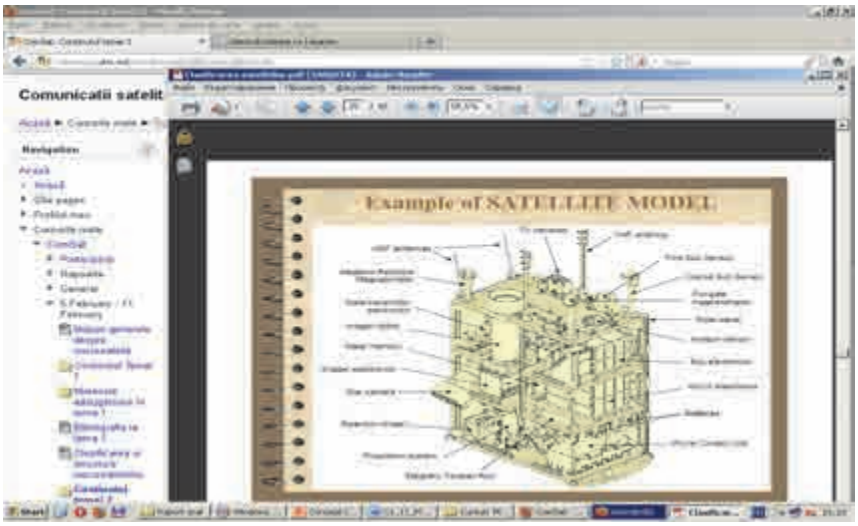

Fig. 3. The Content Presentation in "Satellite Communications“

Quizzes. Quizzes were incorporated in each chapter for students who were keen to self-test their knowledge and learning after the revision of a chapter. Short quizzes in the form of true/false, multiple choice, short answers or numerical questions were assigned, depending on the chapter content. The

majority of the questions were of problem solving type that involved calculation with pre-determined specific units and significant figures of the numerical answers. Two attempts were allowed for each question and the students received immediate feedback if they failed in their first attempt. Positive responses were provided if the students were successful in answering the questions. However, there was no time limit to answer each question as the students were given sufficient time to read and understand the questions, and to answer calmly at their own pace.

Since the quizzes were not part of the students' assessment, it was considered as an independent study at the students' own will. Hence, the quizzes were designed with a due date of two weeks, in order to encourage the students to have a constant revision and to avoid last-minute cramming before examination.

Open Forum. Open forum serves the purpose of allowing a student to post his/her questions or doubts and can be viewed by their fellow peers. This allows the lecturer to disseminate the answered questions to the whole class without repeating in the classroom. Hence, each of the chapters was constructed with their very own Open Forum. Students were also encouraged to use the chat function that facilitated live discussion and interaction with their instructors and peers.

Latest news Message/Calendar. Another interesting feature of Moodle is the function on the right of the webpage which allows the lecturers to post any new messages. It also comes with the list of recent activities so that students can keep-track with any updates. General announcements such as due date of assignments, examination dates and venues, replacement classes etc. were posted at this section and these were linked to the students' email accounts, so that they were notified of every update.

3. General Presentation of Open Educational Resources and MOOCs

Open Educational Resources (OER) have the potential to broaden access to education and to improve the quality and cost-effectiveness of teaching and learning in Europe. The best way to put OERs into practice is through Massive Open Online Courses (MOOCs). MOOCs are large-scale courses that represent one of the latest developments in open education, an initiative that is always trying to improve quality, access and equality in education and training.

MOOCs can be implemented in formal, informal and non-formal learning, and make learning ubiquitous.

Project will use leading-edge technology to create a combined Moodle MOOC platform– based on individual platforms and resources provided by project partners – making it possible to combine and transfer pilot activities in all the hubs involved.

Project will contribute to increasing awareness of the advantages of open education in Europe. The project will prove the potential of MOOCs (courses and communities) for breaking down technological barriers in learning across people with special needs or at risk of exclusion.

MOOCs adopted definition: MOOC is an online course designed for large number of participants that can be accessed by almost anyone anywhere as long as they have an internet connection, is open to everyone without entry qualifications and offers a full/complete course experience online for free.

A MOOC includes educational content, facilitation interaction among peers (including some but limited interaction with academic staff), activities/tests, including feedback, some kind of (nonformal) recognition options and a study guide / syllabus.

4. Utilising the virtual lessons and laboratory resources for electrical engineering

Teaching electrical engineering laboratory procedures by means of a virtual laboratory on a personal computer will be much welcome by educational institutions for whom maintaining a hands-on electric engineering lab is not viable due to various reasons. Instructional laboratory simulations can be incorporated in the virtual laboratory resources where students are free to make the decisions they would confront in an actual laboratory setting.

Electrical Engineering and Technology eLearning Resources

Real-life situations and problems are faced by them, where they have to make/take decisions and face the consequences thereof.

The available links to following websites are given below as examples for the teachers to have an idea of such virtual laboratories.

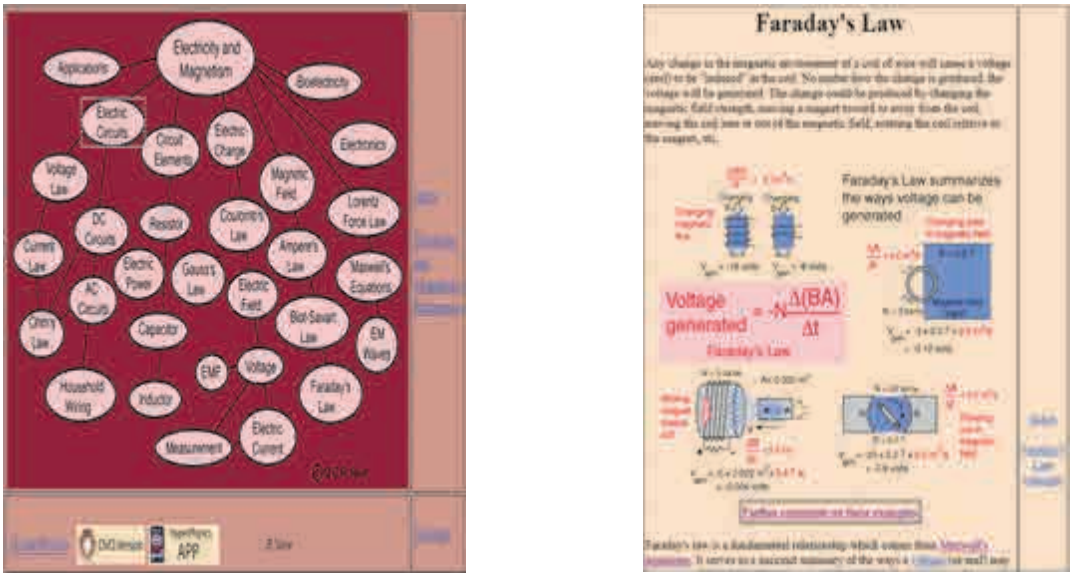

Fig. 4. Hyperphysics, Electricity and Magnetism, http://hyperphysics.phy-astr.gsu.edu/hbase/emcon.html#emcon

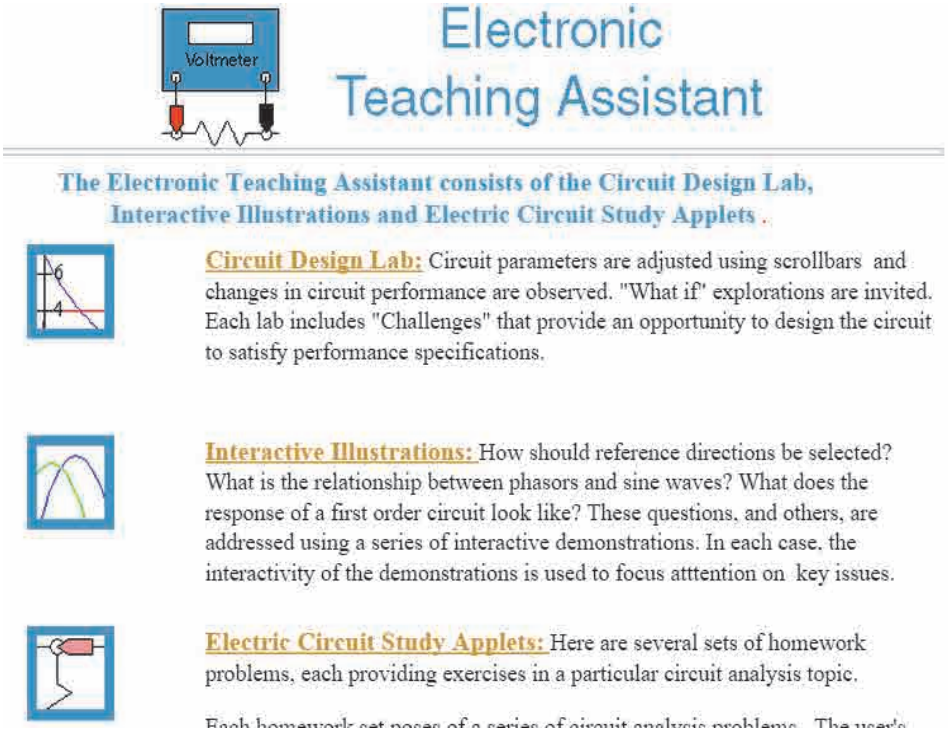

Fig. 5. The Electronic Teaching Assistant: the Circuit Design Lab, Interactive Illustrations and Electric Circuit Study Applets

5. MOOC Electrical Circuit Theory Course Organization

Course organization is based on Bloom's taxonomy of education objectives applied to e-learning of electric circuit theory, see Tables 3a and 3b.

As engineering curricula and courses continue to be restructured due to emerging technologies and ideas, it has become difficult to decide what body of knowledge to be retained and what is to be left out, given that the length of time for undergraduate education is limited to four years.

The selection of e-learning technologies should involve the assessment of course content, learning outcomes, and interaction needs. Olcott (1999) provides what he calls five “Five I’s” of effective e-learning: interaction, introspection, innovation, integration, and information.

Interaction refers not only to the communication that should occur between the student and the instructor and the student with other students but also the interaction between the students and the content of the course. Thus, asynchronous and synchronous communications as well as the presentation of print materials and links to the Internet from the technology needs of interaction. Introspection is the interpretation, revision, and demonstrated understanding of concepts. Discussion boards and graphics can be effective technologies to encourage introspection. Innovation refers to the ability of instructors to experiment with technologies to address various learning styles.

Thus, combination of audio, video, and asynchronous discussion can provide various opportunities for students to learn. Integration reflects the integration of facts, concepts, theories, and practical application of knowledge. Using case studies, print exercises, and role-play can create a setting in which

integration can occur. Information refers to the knowledge and understanding that is a prerequisite for students to move to the next level of learning.

1. Sample Instructional Objective for Circuit Analysis

1.	Be able to explain basic concepts in electrical engineering: - Give a descriptive definition of an electric circuit. - List electrical and magnetic quantities, their units, and symbols. - Use scientific and metric unit notations. - Describe the relationship among the basic quantities in electric circuit theory: charge, current, potential, voltage, work (energy), and power - Distinguish between passive and active circuit elements
2.	Be able to explain experimental and basic laws: - Explain Ohm's law - Calculate current, voltage, and resistance in a circuit; for elements in series, parallel and combinations of both. - Derive the conditions for voltage and current division. - Explain Kirchhoff's current and voltage laws. - Apply Kirchhoff's current law to determine an unknown branch current. - Apply Kirchhoff's voltage law to determine an unknown voltage drop.
3.	Be able to apply methods of network (circuit) analysis
4.	Be able to apply circuit theorems to analyze circuit.
5.	Be able to use operational amplifiers as active circuit components
6.	Be able to describe the structure and characteristics of energy storage elements (capacitors and inductors)
7.	Be able to relate sinusoids, phasors, and complex numbers to circuit elements and variables.
8.	Be able to apply Ohm's law and Kirchhoff's laws in AC circuits
9.	Be able to determine sinusoidal and pulse response of RC circuits.
10.	Be able to determine sinusoidal and pulse response of RL circuits.
11.	Be able to analyze basic RC and RL filters.
12.	Be able to explain the concept of electromagnetism, magnetic induction, and mutual inductance.
13.	Be able to describe the construction and operation of transformers.
14.	Be able to analyze circuits with transformers.

The instructional objectives provide the basis for instructional activities in and outside of the classroom. For each class, the students come in with different learning styles and capabilities. Variation in learning styles of the students can be addressed through course organization. At this point, course organization is generally at the prerogative of the instructor who teaches the course. However, there is a general consensus and effort is being mounted by

all faculty members to adapt instructional techniques that enhance student learning in and out of the classroom. It is therefore the instructor who is required to take into consideration the different learning styles and the teacher builds the class presentations around a hybrid of pedagogical techniques so as to accommodate all the students enrolled in the course.

Shown in Table 1 is a sample of course objective for Circuit Analysis. It is obvious from the objectives that this is not the traditional first circuit course in a typical Electrical Engineering program. Also note worthy is that only the first two sets of objectives are written out in detail. The objectives indicate things that the student must be able to do at the end of the course.

It is pertinent to call the reader's attention to the entries in the instructional objective Table 1. The writing of instructional objectives or course objectives is an elaborate exercise that takes a lot of time. Generally, the instructional objectives are divided into weekly activities and entered into the course calendar.

The basic outline of the course consists of Content Building Blocks (Table 2).

2. Course Content Building Blocks

Content	Circuits Analysis
AC Fundamentals	BK/ AP
DC Fundamentals	BK/ AP
Circuit Theorems	BK/ AP
Complex Numbers	BK/ AP
Energy Storage Elements	BK/ AP
Transients	BK/ AP
AC Power Analysis	BK/ AP
Three-Phase Circuits	BK/ AP
Magnetically Coupled Circuits	BK/ AP
AC Steady-State Analysis	BK/ AP
Analog Filters	BK/ AP
Fourier Transforms	BK/ AP
Laplace Transforms	BK/ AP

BK = Basic Knowledge

AP = Application

Some helpful strategies for establishing education objectives for on line courses are:

a) Establishing online threaded discussions that deal specifically with assignments and projects;

b) Establishing course projects that:

- require problem finding and problem solving, not only the rote memorization of facts and information; and
- challenge everyday thinking to address diverse perspectives on issues;

c) Establishing learning outcomes that translate to and have lasting benefit to real-world practice.

Create conditions for a knowledge sharing community to emerge and create as many opportunities for others to learn your infrastructure for knowledge sharing.

3A. Bloom's Taxonomy of Education Objectives

Six categories of learning	(1) Knowledge / Remembering	(2) Comprehension / Understanding	(3) Application
Student	Simple Memory/General knowledge	Student knows and understands information.	Student knows, understands, and uses information.
Computer Tool:	Drill and Practice.	Visualization software, tutorials	Internet research, Databases, Spreadsheets, Simulations
Internet Task:	As students read articles and triangulate to determine the accuracy of facts, they learn the facts.	In order to avoid plagiarism, students must summarize information and relay it in their own words.	The use of an Internet based simulation / game would be useful here.

3B. Bloom's Taxonomy of Education Objectives

Six categories of learning	(4) Analysis	(5) Synthesis / Creating	(6) Evaluation
Student	Student knows, understands, uses and critically examines information.	Student internalizes information to generalize about and beyond what is known.	Student judges known and/or hypothesized information
Computer Tool:	Presentation Software, Visualization Software, Databases, Spreadsheets, Simulations	Presentation Software, Word Processing	Presentation Software, Word Processing, Internet Research
Internet Task:	During the process of triangulation, students must examine, compare and test information and ideas for accuracy and logic	When students write their report, they create a new piece of work compiling ideas and facts as well as generating conclusions.	When students write a conclusion for their report they judge among competing ideas and draw a conclusion.

The numbers in parentheses are based on the six categories of learning from Bloom's Taxonomy of Education Objectives.

Traditionally, categories (4)–(6) are considered more challenging, requiring higher level thinking skills.

As examples we considered :

- the objectives for chapter ac power analysis (1 introduction; 2 instantaneous and average power; 3 maximum average power transfer; 4 the effective value; 5 apparent power and power factor; 6 complex power; 7 conservation of ac power; 8 power factor correction; 9 applications; 9.1 power measurement; 9.2 electricity consumption cost) and the objectives (see Table 4) for the review of single-phase power and power factor correction, (• solve for the real, reactive, apparent, and complex power of a circuit and determine the power factor (leading or lagging); • use the power triangle to relate the power components of a given circuit;

• explain the purpose of performing power factor correction;

• determine the reactive power and capacitance required to obtain a specified power factor, see figure 2).

4. Objectives for chapter ac power analysis

(2) Comprehension	(3) Application	(4) Analysis
Describe (2) how the power triangle for a given circuit relates to the impedance components on the complex plane. Describe (2) how the power triangle for a given circuit relates to the impedance components on the complex plane. Explain (2) the purpose of doing power factor correction.	Solve (3) for the instantaneous power p(t), average (or real) power P, reactive power Q, apparent power S, complex power S, and power factor for any of the elements of an AC circuit. Use (3) the power triangle to describe the power components of a given circuit or element.	Explain (4) the physical meaning of instantaneous power, average power, reactive power, apparent power, complex power and the power factor (leading or lagging).

Conclusions

This paper is a synthesis that presents the conception of a project devoted to use moodle Virtual Learning Environment for the development of MOOC courses which mainly contains OER materials in order to educate the Engineering Students.

Engineering School teaching and students' learning are moving through transition processes that use education technology in support of academic work. There exists a greater acceptance of the online mode of instruction as an adjunct to learning. Nevertheless, the results of our work showed that most students preferred a moderate use of e-learning in their courses. Their positive attitude was observed towards the model of blended learning approach, and Moodle platform

did create a positive impact on students' learning experiences in terms of the accessibility of learning materials and the support of online assessment activities.

Students reported that the most valuable benefits of using Moodle platform in learning EET were the convenience of accessing the course materials and completing the online assessment tasks. Overall, the majority of the students perceived the use of course website as an opportunity to enhance their academic experience.

Although the students agreed that the hybrid learning provided them with the needed assistance, one of the drawbacks observed was that this method of delivery was prone to become a one-way communication. Responses to this study showed that the number of the students' email correspondences to the lecturers were minimum. The students were expecting to be "spoon-fed" with information, announcements and notes. Thus, a more interactive learning is needed to promote a two-way communication. Communication tools such as forum discussion and online chat room have the features that create interaction with instructors and among the peers.

However, as mentioned earlier in the study, most students are likely to participate in the learning practices only if the activities are considered as part of the evaluation of their academic performance. It is therefore necessary to assign grading procedure in e-learning activities to increase students' participation. With the improvements at these loose ends, Moodle application in Electrical Engineering will be an invaluable and imperative tool for the instructors as well as for the students.

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УДОСКОНАЛЕНА ТЕХНОЛОГІЯ ЕЛЕКТРИЧНОЇ ІНЖЕНЕРНОЇ ОСВІТИ В КОНТЕКСТІ ПРОЕКТУ CRUNT TEMPUS

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Анотація. *У проекті CRUNT TEMPUS використано методи електронної педагогіки з використанням середовища навчання ІТК. Міжвузівська мережа електронного навчання Молдови використовує віртуальне середовище навчання для вдосконалення навчального процесу та навчання студентів інженерних факультетів. У статті представлені деякі методологічні елементи, які зробили свій внесок в успіх проекту TEMPUS CRUNT.*

Першочергову увагу приділено веб-курсам, заснованим на методології змішаного навчання. У цій статті представлено навчальні матеріали електронного навчання для студентів інженерних факультетів, розроблених на основі Virtual Learning Environment (http://elearning.utm.md/moodle/login/index.php). Модель дисципліни «Електротехніка та технології (EET)» являє собою новий підхід до вивчення електричної технології, яка представлена концепцією її вививчення в звичайному логічному порядку, але ілюструється прикладами, які можуть зацікавити студентів.

Ресурси електротехнічної дисципліни можуть бути використані викладачами і студентами технікумів, починаючи від початкового до просунутого рівня електротехніки і технології. Викладачі знайдуть надійні та якісні ресурси, включаючи відео, статті, демонстрації, робочі листи, оцінку навчання, які знаходяться в одному місці. Ресурси можуть бути знайдені за темами і стандартами. Модулі електронного навчання використовують візуалізацію електротехнічних концепцій.

Ключові слова: потужність при несинусоїдальних режимах, вимірювання електричної потужності при синусоїдальному, несинусоїдальному, рівномірному або нерівномірному навантаженні, забруднення енергосистем гармоніками

УСОВЕРШЕНСТВОВАННАЯ ТЕХНОЛОГИЯ ЭЛЕКТРИЧЕСКОГО ИНЖЕНЕРНОГО ОБРАЗОВАНИЯ В КОНТЕКСТЕ ПРОЕКТА CRUNT TEMPUS

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Аннотация. *В проекте CRUNT TEMPUS использованы методы электронной педагогики с использованием среды обучения ИТК. Межвузовская сеть электронного обучения Молдовы использует виртуальную среду обучения для совершенствования учебного процесса и обучения студентов инженерных факультетов. В статье представлены некоторые методологические элементы, которые внесли свой вклад в успех проекта TEMPUS CRUNT.*

Первостепенное внимание уделено веб-курсам, основанным на методологии смешанного обучения. В настоящей статье представлены учебные материалы электронного обучения для студентов инженерных факультетов, разработанных на основе Virtual Learning Environment (http://elearning.utm.md/moodle/login/index.php). Модель дисциплины «Электротехника и технологии (EET)» представляет собой новый подход к изучению электрической технологии, которая представлена концепцией ее изложения в обычном логическом порядке, но иллюстрируется примерами, которые могут заинтересовать студентов.

Ресурсы электротехнической дисциплины могут быть использованы преподавателями и студентами техникумов, начиная от начального до продвинутого уровня электротехники и технологии. Преподаватели найдут надежные и качественные ресурсы, включая видео, статьи, демонстрации, рабочие листы, оценки обучения, которые находятся в одном месте. Ресурсы могут быть найдены по темам и стандартам. Модули электронного обучения используют визуализацию электротехнических концепций.

Ключевые слова: мощность при несинусоидальных режимах, измерения электрической мощности при синусоидальной, несинусоидальной, равномерной или неравномерной нагрузке, загрязнения энергосистем гармониками