Design of university e-course in Electronics for future engineers

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Abstract: This article describes the process of designing the model for e-learning and the current design of a university course in Electronics for second-year students in Industrial engineering major of ELFE at Technical University-Sofia. The described process involves analysis of the reasons for the development of the model, analysis of the theoretical, methodological and technological aspects and conclusions of the preliminary studies of the academic environment. Virtual tools implemented in LabVIEW graphical programming environment are integrated with the e-course in Electronics. The functions of the studied device to be simulated are selected very precisely and they are adapted for use at the right time on the right level of training. Simulation models implemented as a virtual experiment add a new emphasis which is usually not sufficiently covered in the traditional exercises, thus posing a problem for students.

Key - words: E-learnin*g,* Distance learning, Course design, Methodological frame

1 Introduction

New approaches and strategies for teaching and learning have been implemented over the last years, in the context of the accelerated development of information and communication technologies, including the training of future engineers. The use of contemporary information and communication technologies (ICT) enables the universities to offer more flexible training in comparison to the traditional forms, while striving for a higher quality of the training process [1].

Good university electronic information infrastructure is essential for the development of e-learning (EL). The building of a structure for consultation and support of the academic staff in the design and implementation of EL is a key factor in the development of this type of training. Provision of efficient e-course for the preparation of future specialists in the engineering field is crucial for the successful realization in the labour market.

E-learning refers to the electronic process of knowledge acquisition and includes web-based training, computer-based training, virtual classroom, articles and digital collaboration.

Over the past five years, the educational policy of many of the leading universities both at home and abroad tends to combine or replace traditional with distance form of learning.

This trend is set out in the strategy of TU-Sofia, as well, which is aimed at offering a quality e-learning to its students. Traditional education at TU-Sofia is usually organized in attendance form and under contemporary conditions, distance learning is exclusively in electronic form. E-learning courses have a beneficial impact on full-time training and are a good means for its conduction, among other things for the training of future professionals in the field of engineering. Thus, the opportunities for self-preparation and self-study of the students are also expanded.

Here we should make it clear that the term “e-learning” is not synonymous with the term “distance learning”. It refers to the aforementioned traditional forms of education which use elements of digitalisation in the day-to-day training process.

Since the e-course in Electronics is focused mostly on trainees and the formation of specific professional competencies, we have chosen the most effective form of training, the blended learning. This combination avoids limitations in respect of pedagogical interaction between the learner and the lecturer. The lack of direct contact during the e-learning is compensated by chat, blogs, Skype, forums etc. within the e-course.

We have selected the blended learning as a working model to be applied in the training of future engineers since this is flexible learning where the learner has a certain opportunity for choice in terms of various parameters of the training process (time, place, means, training content etc.). This is a kind of “complex” of traditional education by means of synchronous online training or discussions, asynchronous individual learning and structured practical learning with the help of a lecturer. Therefore, the virtual learning environment (VLE) has auxiliary functions (resource storage or for discussions only) to the traditional learning. Our motives for choosing this type of e-learning are related to the specifics of the Electronics course for future engineers which are associated with the formation of a specific subject and practical skills in the traditional environment.

The e-learning platform Moodle is suitable for this type of learning since it sets the framework for the development of e-courses and conduction of blended type of learning.

2 E-Course Design in Electronics

The course in Electronics is part of the mandatory courses for second-year students, full-time form, in Industrial engineering major of ELFE at Technical University-Sofia. In the course of redesigning the traditionally organized course in Electronics into e-based blended type, we stuck to these stages:

1. Identifying the profile of learners. One of the first steps before the actual design of an e-course is related to the research of students' needs. For this purpose, we developed surveys through which we identified students' motivation to study within the course, the manner of studying, the level of cognitive experience in terms of use of contemporary technologies, as well as the preferred means of obtaining feedback and the types of training activities organized in e-environment.

2. Design of the e-course which includes the design of learning activities and learning resources; instructions for communication and resources for management of learning.

3. Diagnostic procedure for the study of changes in learning achievements and reasons for learning, developed by the learners resulting from the application of the established model for e-learning.

The dominating theoretical and methodological theory on which the design of e-learning is based is constructivism.

One of the main paradigms of constructivism is the one of social constructivism. Representatives of social constructivism emphasize that social interactions are an essential component of learning which always takes place as a dialogue. To this sense, the role of the trainer, or rather of the lecturer assisting the learning process, is to construct the training around the personality of the learner, to stimulate and guide them in accordance with their development. Constructivism is based on the idea of learning through discovery [2]. The methodological approach of constructivism is seen in the light of contemporary reality, that is, active use of new technologies as one of the possible options for active learning, such as within the e-course in Electronics. Future engineers construct their own knowledge and competencies through experience within various learning activities organized in the environment Moodle. This enables learning to be organized as a process resulting in modifications in internal structures, hence in the formation of professional competencies of future professionals. This is learning by means of “fitting/matching/ integration” of new knowledge into already existing knowledge structures. Constructivism is focused on the training of the learner how to solve in ambiguous situations of choice. New technologies position training of learners before new challenges: more flexible and efficient process of learning in terms of time (transition from discrete to a continuous model of learning); access to information and variety of knowledge; a wider range of sources of knowledge.

Part of the learning activities in the e-course in Electronics are organized around learning through experimenting and discovery (Discovery Learning); learning through inquiry and information search (Inquiry Learning); learning to critical thinking (Critical Thinking Learning). The design of the aforementioned learning activities derives from constructivism requirements which are the theoretical framework of the e-course.

Following a research on various design models of university e-courses, we selected the model of Peter Goodyear as an entry point for our design. Goodyear defines e-learning as learning in a network and emphasizes the need to distinguish between the terms “learning task” and “learning activity” [6]. His model has two design levels: macro design outlining the theoretical and methodological framework of course organization, and micro design summarizing the elements of the projected pedagogical reality. An important component of Goodyear’s model is the organizational context where both design development and application are implemented. The author stresses on the fact that the quality of e-learning depends on the advantages and interdependence of the three elements - theoretical and methodological framework, pedagogical reality and organizational context. Using Goodyear’s model as a base, we developed the theoretical framework of our course, while adhering to the philosophy of social constructivism.

Development of this e-course in Electronics features two stages, corresponding to the two design levels: macro design and micro design.

Macro design covers the level of curricula planning. At this level, the lecturer defines the methodological approach, aiming at creating theoretical approaches: objectives design, expected results, content, assessment of students’ performance and quality of the course [3, 4].

Micro design is associated with the planning of each individual activity (its organization, structure and content) and the relations between activities in operational terms, so that their consistency results in the achievement of the course objectives [3, 4, 5]. The particular micro design is designed in accordance with the specifics of the course, on the one hand, and the potential of the selected virtual environment, on the other hand, which shall be implemented as part of students’ activities; in this particular case the e-platform is Moodle. Essentially, learning content is divided into separate topics.

The course design includes four constructive modules for each topic: theoretical, practical, quiz and a module of additional literary sources.

The main constructive elements of the theoretical module are video lectures, presentations, pdf files, links to additional materials for particular topics and information block.

Virtual instruments implemented in LabVIEW graphical programming environment are integrated with the Practical module. The functions of the studied device to be simulated are selected very precisely; they are adapted for use at the right time on the right level of training.

This module involves individual and group tasks, a protocol for each laboratory topic, individually drafted by each student based on a framework set by the lecturer, discussion forums and a glossary filled in by students themselves in the course of learning.

The Quiz module includes a set of thematic issues on the base of which students can make a self-assessment of the knowledge they have acquired following a successive covering of all modules on a particular topic.

Also, each studied topic is accompanied by literary sources as additional material for students.

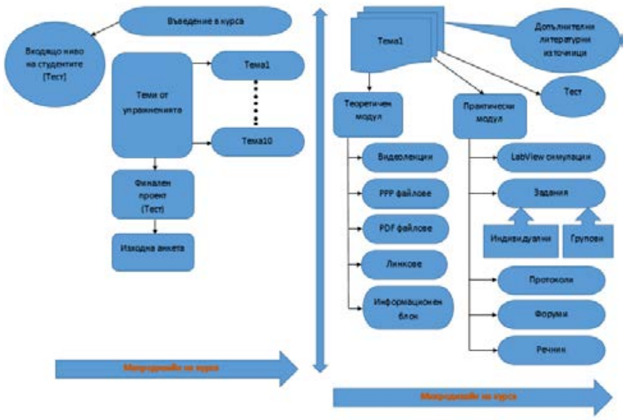

Fig.1 Model of e-course in Electronics for students - future engineers

Following the training documentation (curriculum) developed for the traditional attending form of education, we redesigned the course from traditional into an e-course, and designed the course on a macro level observing this consequence of steps:

- activities planning and research and analysis tools for the needs and entry level of students;
- planning of the macrostructure of the course (main objectives, expected learning outcomes, main topics of the curriculum, time schedule - beginning and end of the course; learning time - 1 credit is equal to 30 classes, number of students, preconditions for enrollment, assessment system);
- planning and use of technologies: prerequisites for available technologies to be used in the course.

The following main modules are implemented on macro design level of the course: an introduction to the course and evaluation of the entry level of the students by means of an entry survey; studied topics; final project - final assessment by end result; exit survey. The description of the macro design of the e-course in Electronics in terms of objectives and expected learning outcomes covers two main directions: knowledge and skills and competencies which students have to acquire following the completion of this course. The course in Electronics

provides fundamental knowledge on the most widely used semiconductor elements, circuits and systems of analogue and digital electronics. Following the successful completion of the course, students acquire skills and competencies in the sphere of semiconductors and semiconductor elements; discrete analogue electronics - amplifiers, generators, rectifiers, filters, stabilizers, analogue integrated circuits - operational amplifiers, linear and non-linear applications; digital systems - combinational logic, logic of sequences, digital elements, memories; digital-to-analog and analog-to-digital converter - specifications, systems with DAC and ADC. Main curriculum topics studied in the e-course are: Operational amplifiers. Basic circuits I; Operational amplifiers. Basic circuits II; Comparators and generators; Binary numbers. Basic logical operations; Combinational logic. Karnaugh maps;
Arithmetic devices; Trigger register; Counters; Digital-to-analog conversion (DAC); Analog-to-digital conversion (ADC).

The course is taught in the third semester in Industrial engineering major of ELFE at Technical University-Sofia and has two classes per week for lectures and laboratory exercises, whereas lectures precede the exercises as a rule. The number of credits is 5, i.e. 150 classes in total.

The precondition for enrollment in the course is knowledge in the following areas: mathematics, physics, theoretical electrical engineering and very good command of English.

Formative and summative assessment is planned with regards to the assessment system within the particular course. Summative assessment takes place after each course topic and final assessment by the end result, while formative through quizzes for self-assessment, as the case may be. Lecturer provides feedback on a regular basis within the e-course.

Virtual instruments developed in LabVIEW graphical environment are created and implemented in the Practical module on micro design level of the e-course. Simulation models of studied devices implemented as a virtual experiment fully represent each of the stages of solving the experimental task. They add a new emphasis which is usually not sufficiently covered in the traditional exercises, thus posing a problem for students.

To illustrate the execution of an exercise in “Electronics” – a study of operational amplifiers using LabVIEW, screenshots of the front panels involving some of the realized virtual instruments are shown in the following figures (Fig. 2 to Fig. 4).

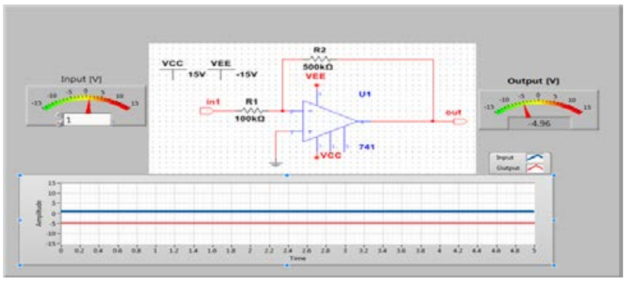

Fig. 2 Inverting amplifier

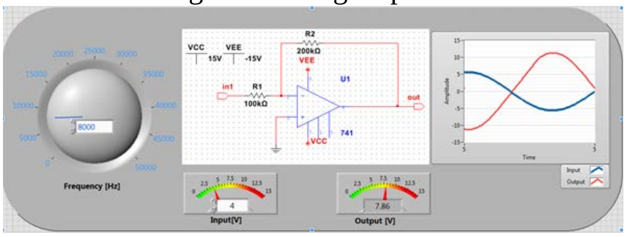

Fig. 3 Frequency response of the inverting amplifier

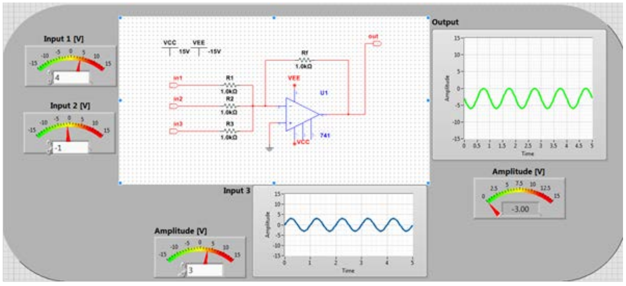

Fig. 4 Inverting adder

Simulations are valuable tools for teaching technical subjects. In many cases however simulation cannot (and should not) be used for each topic and course of the training. In order to ensure that learners will benefit the most from simulations, the following should be observed:

- to select exactly the features to be simulated;
- to plan at which stage of the training they shall be used;
- to be combined effectively with other types of instructions for building a training software. Simulations can be combined with other types of e-learning.

In order for the simulation to achieve its objectives within the education cycle, it has to be integrated with the overall training so as to be adapted for use at the right time on the right level of training.

Some of the reasons to use this technological solution are modular designing of the courses, interface in Bulgarian, ability to work in a group environment stimulating “the social constructivism” etc.

7 Conclusion

The efficient theoretically based design of the e-course (including Electronics) provides an opportunity for various approaches and methods for interactive cooperation both between students and curriculum and between students and lecturer. This cooperation results in the formation of specific professional competencies, on the one hand, and the so-called “flexible skills”, on the other (teamwork, communicability and skills for personal presentation, digital skills etc.).

On the basis of the good experience regarding the design and implementation of e-courses in the training of future professionals, including engineers, we can summarize the following advantages and opportunities, namely: improving the quality of university education; expanding the accessibility and removing barriers for educating various groups of students (including those with special educational needs); formation of professional competencies in the context of person-oriented flexible training.

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