Developing an E-learning Course for Teaching Digital Technology

Nikoletta Tolner and András Dávid

Campus of Alba Regia Technical Faculty of Óbuda University
H-8000 Hungary Székesfehérvár, Budai str. 45, Hungary
tolner.nikoletta@amk.uni-obuda.hu
david.andras@amk.uni-obuda.hu

Abstract: We have been teaching Digital Technology to full time and correspondent students for several years. Based on this experience, we attempted to compile a course that is easy to use. We also took into consideration the fact that our students' needs have changed. We use the MOODLE system at the Obuda University, so we developed Digital Technology Course 1. and 2. within the frames of this system. Our courses cover the same topics that are taught to full time electrical engineer students in their courses with the same name. In the beginning Digital Technology 1. and 2. were only used in the KMOOC system (Carpathian Basin Massive Open Online Courses), as an optional subject. Now we also use it in full time education as a supplementary material, with certain necessary alterations. In the present article we describe the process of developing the courses, and also our experiences of using them.

I. INTRODUCTION

A) The subject of Digital Technology in brief

Digital Technology is a subject that we teach at Obuda University to Electrical Engineering, Informatics Engineering and Engineering Management students. It is a foundation subject, part of the core material. Electrical Engineering students study Digital Technology I. in the first term in the following schedule: 2 lectures and one lab practice lesson per week (4 credits). In the second term Digital Technology II. takes up 2 lectures per week (3 credits).

Informatics Engineering students study Digital Technology in the second term in 2 lectures and 2 lab practice lessons per week (4 credits).

Engineering Management students study the subject under the name of Analog and Digital Technology in 2 lectures and 2 lab practice lessons per week (5 credits). The main aim of the subjects is to give basic hardware knowledge required for designing digital circuits. To this end, students deepen their theoretical knowledge though practical tasks.

During the course students

- Learn about Boolean algebra, the mathematical language used for describing the operation of networks
- Learn about the main types of circuit components
- Learn and practice the steps of designing combination networks
- Gain knowledge in identifying and eradicating hazard phenomena
- Learn about the operation of arithmetic circuits
- Learn about the operation and description of sequential networks
- Get knowledge of elementary synchronous and asynchronous sequential networks
- Get knowledge of and practice the steps of planning sequential networks
- Learn to identify and eradicate competitive situations
- Practice how to analyse time operation of sequential networks
- Learn about different types of memory, and how to use them for planning sequential networks

B) Survey of student needs

We tried to gauge student needs before developing our supplementary materials. Although the survey was not representative, we got some significant results:

The supplementary materials should be

- electronic, rather than printed
- easy to reach anywhere and anytime
- short, concentrating on the essence of the material
- theoretical material should be supplemented by practical examples and exercises
- it should contain self-monitoring tasks providing immediate feedback

We all know that students' learning habits have changed. Research of teaching methodology has also produced new results. More and more educational institutions are developing an electronic curriculum.

In the field of public education, the work of the Education Research and Development Institute (OFI) is outstanding. This institute has developed new textbooks, supplementary materials and teaching aids, among which you can find electronic materials [1], too. Higher education institutions also began to develop electronic curriculum. The Hungarian Virtual University Network Association has been formed to represent the e-learning system of 19

higher education institutions. Obuda University is also a member of this Association [2].

The Association aims to establish a cooperation framework that provides support for the development of distance learning and e-learning.

II. GOALS AND OBJECTIVES

A) The development objective

Taking into consideration students' needs, we started developing the curriculum. Several teaching methodology questions arose during the process. Our main goal was to create a material that is best suited to meet the needs of the student. We studied the possibilities of developing e-learning materials, as this was one of the students' requests. At that time, an opportunity emerged to use our material as an elective course in KMOOC. Our application was accepted, so we modified the material in a way that it could be used as an independent online course. As a result of this work, Digital Technology I came out in September 2015., then Digital Technology II. in September 2016. The material of the two courses completely covers the same courses for Electrical Engineer students. The two courses are worth 4 credits.

B) Steps of developing the e-learning course

1. We studied resources on how to compile easy-to-use e-learning materials. [3], [4], [5]
2. We tried to use this knowledge for the topic of Digital Technology. The basis of our material was a course book written by one of our colleagues. [6]
3. We also studied already existing e-learning materials available at Obuda University.
4. We looked for tools and programs that could be used for designing and testing digital circuits. Logisim [9], [10].
5. We created Digital Technology I. online course.
6. Digital Technology I. had been successfully operating for a year, when we created Digital Technology II. (It was also realized within the frames of KMOOC.)
7. We built in the material of online courses into the curriculum of full-time Electrical Engineering students. It is used as a supplementary material in full-time education.

III. METHODS

A) What kind of e-learning materials can you find?

E-learning materials available in higher education are usually in pdf format, with a few self-test questions at the end. They do not really meet students' needs. A smaller part of materials contain theoretical explanation, practical examples and self-tests, too.

B) The possibilities offered by Moodle

Obuda University uses the Moodle system, so we created Digital Technology I. and II. courses in this system. Moodle is a freely available e-learning framework, written in PHP language [7]. There is a "community-based, globally supported Moodle community" [8], which provides its members with useful information.

First we had to find out what opportunities are provided by this system. What kind of educational materials, activities and tests can we include in our material?

We have created a question bank containing nearly 1,500 questions. Then we compiled self-tests and knowledge evaluation tests using this question bank. We used the following types of questions and tasks: embedded answers, essay, multiple choice, true or false, open ended questions, matching tasks, select missing words, numerical, drag and drop onto image and drag and drop into text. We also created video materials: animated ppt and classroom videos. We also set complex requirements for students to pass the test.
Questions are randomly selected for midterm tests and final tests, so it cannot happen that one student gets the same question twice.

C) Logisim [9], [10]

During the development of the courses we considered it important that students can test and simulate the operation of the designed combination and sequential networks. We looked for a program that is free, easy to learn, and is suitable for simulating combination and sequential networks. After examining several programs, we chose Logisim. At the beginning of both courses we teach students how to use Logisim by the help of videos. This program can be perfectly used for simulating combination networks, it can simulate sequential networks on a basic level, but unfortunately it cannot be used for drawing time diagrams. We created sample circuits for each module, these are available for students, too.

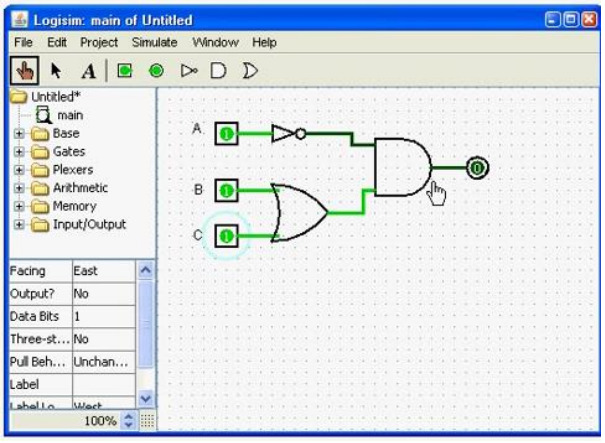

Figure 1: An example of the implementation of a combination network with Logisim program

D) Camtasia program

Camtasia Studio are software suites, created and published by TechSmith, for creating video tutorials and presentations directly via screencast, or via a direct recording plug-in to Microsoft PowerPoint. The screen area to be recorded can be chosen freely, and audio or other multimedia recordings may be recorded at the same time or added separately from any other source and integrated in the Camtasia Studio component of the product. Both versions of Camtasia started as enhanced screen capture programs and have evolved to integrate screen capture and post-processing tools targeted at the educational and information multimedia development marketplace. Camtasia program was also used in the online (recorded) course material (Figure 2,3). Animated ppt files, which can be used multiple functions, has also been produced with this program.

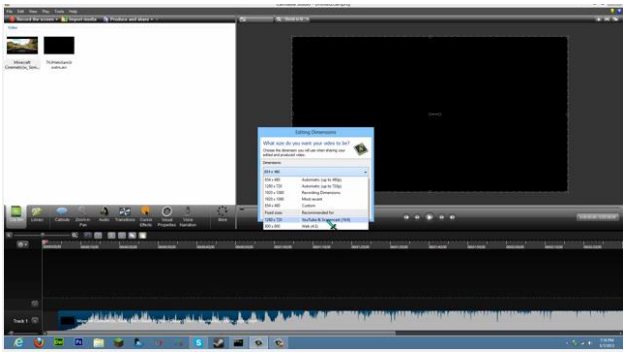

Figure 2: Camtasia Studio program

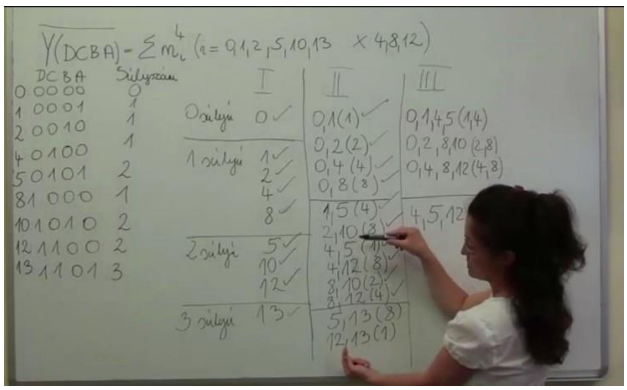

Figure 3: Video with Camtasia program

IV. RESULT

A) Creating online course for Digital Technology I.

After examining the opportunities, the Digital Technology 1. online course was prepared, and was divided into 12 modules (Figure 6 and 7):

Module 1: The concept of logic network and its function, its standard makes, its description opportunities

Module 2: Number systems, coding systems for digital technology

Module 3: The Boolean algebra

Module 4: The logic network, and the description of its function with equations. Disjunctive, conjunctive canonical forms

Module 5: Universal logic functions and implementing these building blocks

Module 6: Simplification of logic functions with Karnaugh table

Module 7: Simplification of logic functions with digital minimization (Quine-McCluskey)

Module 8: Design and analysis of combinational networks. Hazardous phenomena

Module 9: The ideal and the real circuit blocks, the features of the real circuit blocks. TTL and CMOS technology

Module 10: Different types of outputs and their connectivity

Module 11: Multiplexers, demultiplexers

Module 12: Arithmetic circuits

B) Creating online course for Digital Technology II.

Digital Technology I. online course had been operating for a year, when we started to compile Digital Technology II. Because of this we were able to take into consideration the feedback and suggestions we got from our students. Digital Technology II. is also divided into 12 modules.

Module 1: The concept of sequential network, its types and methods of description (synchronous and asynchronous sequential networks, Mealy model, Moore model, state table, state graphs)

Module 2: Basic sequential networks (R-S, Rnegated-Snegated storage, D, T, J-K, J-Knegated flip-flops)

Module 3: Steps of designing synchronous sequential networks

Module 4: Steps of designing asynchronous sequential networks (stable, unstable states, critical, non-critical conditions)

Module 5: Designing a synchronous sequential network using flip-flops

Module 6: Designing networks with shift register (ring, Johnson, modulo numerator)

Module 7: Designing networks with synchronous counters

Module 8: Designing networks with asynchronous counters

Module 9: Examination of the operation time of synchronous sequential networks

Module 10: Time operation of synchronous sequential circuits with shift registers

Module 11: Time operation of synchronous sequential circuits with synchronous counters

Module 12: Memories and their usage in sequential circuits

In the beginning of the course students can see only Module 1. They can go on to the next module only if they reach the required result in the Final Module Test. The required results are the following:

Digital Technology I.

Modules 1, 2, 3, 4, 5, 9: minimum 60%

Modules 6, 7, 8, 10, 11, 12: minimum 50%

Digital Technology II.

Modules 1, 2: minimum 60%

Modules 3 to12 minimum 50%

If students reach the required results in the first 6 Final Module Test, they can sit the first Mid-term Test. They can go on studying the next modules even if they fail the first Mid-term Test. The structure of all modules is the following (Figure 4.):

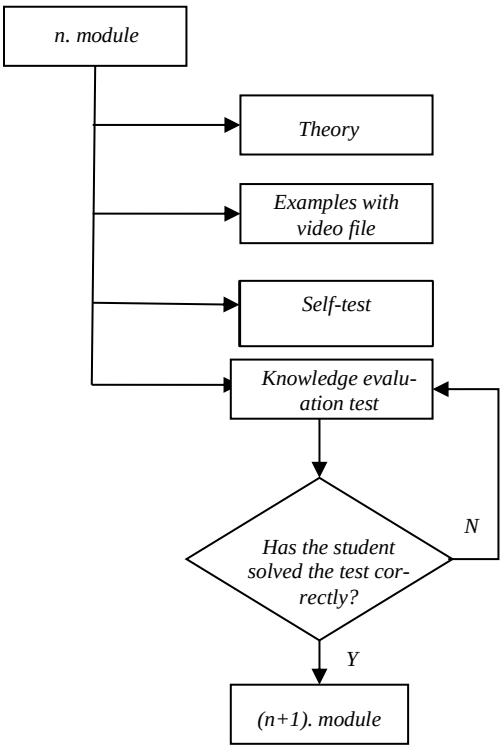

Figure 4: The structure of modules

The order of the modules is carefully designed, we recommend students to study the modules in the given order. They have to understand the theoretical part first, then they can move on and study the practical examples. Video materials are also provided, so students can follow a teacher's explanation, as if they were sitting in a classroom. The next step is the self-test, which gives students opportunity to evaluate their knowledge of the module. It is possible to do the self-tests (Figure 5.) several times, so students are given the possibility to practise their skills. Then they can do the Final Module Test, which is marked by teacher. This kind of test can be done only 3 times (in the case of the first 3 modules) or twice (in the case of rest of the models).

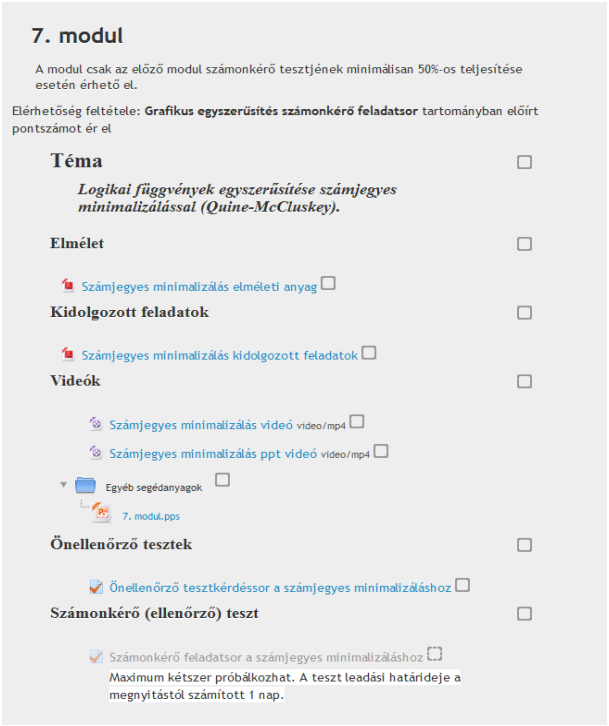

Figure 5: An example an module of the Digital Technology I. online course

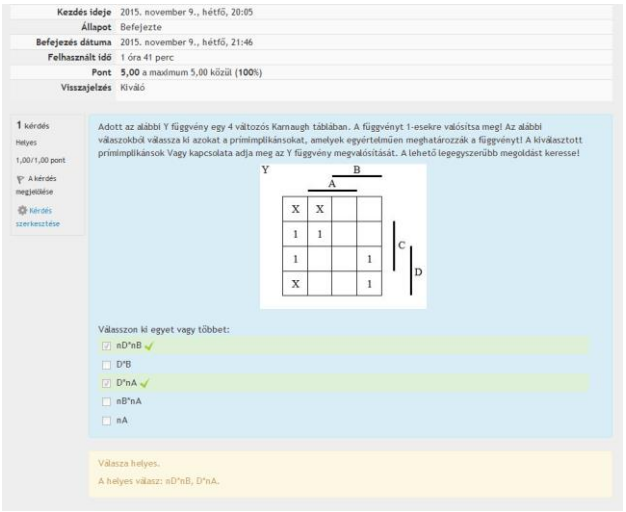

Figure 6: An example of a self-test of the Digital Technology I. online course

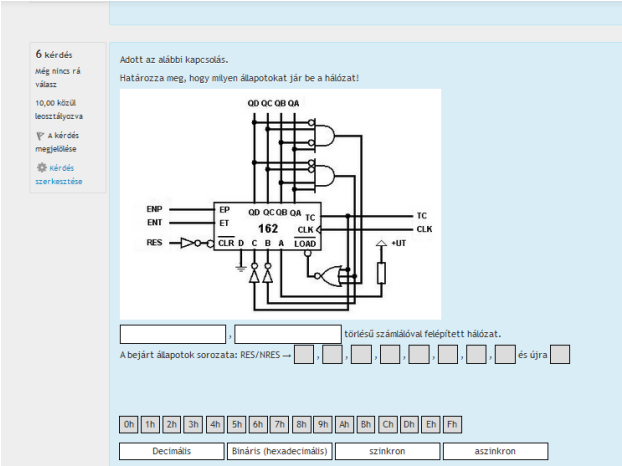

Figure 7: An example of a Final Module Test of the Digital Technology II. online course

C) *Evaluation of students' achievement*

For both courses we designed two mid-term tests, one after the 6th, the other after the last module. Mid-term tests can be reached by students only on certain days and only for a certain period of time.

We did not give a time limit for studying the modules, as our experience is that students can learn the material in their own pace. Giving a time limit puts unnecessary stress on students with a slower pace. Most mid-term tests are designed in a way that students can get immediate response about their result (passed of failed). Some tests are more complex and have to be marked by a teacher, which takes more time.

Completion of the course will be considered successful if students pass all their tests and do their written homework with the required result. If students fulfil these conditions, they get a mark from their teacher. The mark is based on the following results:

30% of the mark: written homework and Final Module Test results

70% of the mark: Mid-Term Tests results

Mid-term tests must be written by students at the University Campus. Obuda University's goal is to provide students with the opportunity to study all subject online, not only the elective courses.

V. *Discussion*

A lot of work is also associated with not only the creation, but with the management of an online course. Certain tasks cannot be evaluated automatically. The teacher has much work after the completion of the course. It is necessary to correct the incoming tasks, it is necessary to have information about the results. This should be done completely electronically. In the regular full-time education, a lot of things can be used from the online course material. In this case, personal feedback can be provided, which can be interpreted more precisely. In the case of an online course the teacher has no chance to check whether it was the registered student or someone else who solved and sent in the Final Module Test.

VI. *Feedback from students*

Students achieve surprisingly good results when doing Final Module Tests of elective courses. This can probably be explained by the fact that only those students choose these courses who are really interested in the topic. We keep receiving a lot of positive feedback from students, they also point out errors if they discover any. We try to correct these errors as quickly as possible. We started using the course materials in full-time education in 2016 and so far we have received only positive feedback.

VII. *References*

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