International Conference on Signals and Electronic Systems
September 13-15, 2004 Poznań, POLAND
ICSES'04

A Course in Basic Digital Electronics for a Distance Educational Programme

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Abstract - **In this paper the design and implementation of a course in basic digital electronics for distance learning is described. The course is intended to be flexible in order for the students to follow course without restrictions in time and location. The paper discusses flexible lectures, laborations, forms for examinations, and communication between and among students and course instructor. The course is a part of the Swedish nation-wide distance educational program in electrical engineering.**

I. INTRODUCTION

In order to broaden the possibilities for new groups of students to enter study programs at the universities, courses based on distance learning is an important way to achieve this. For adult students who work, have families, and live in rural areas, distance learning is often the only way for getting an eduction. *Flexibility* is the key issue when designing a course. The course must be design in such way that it fits in to schedules set by work and family and overcome geographical distances. Also on-campus students may find these courses valuable to resolve course scheduling conflicts with other courses.

In comparison to on-campus courses normally based on lectures, distance learning courses have to a large extent rely on technical aids. Internet based tools are obviously the most important technology when broadband subscription becomes available to a large part of population to a reasonable cost. The open question is how to use these tools for bridging the distances in location and time. There are many ways to organize a course with respect to organizing lectures, examination, interaction with students and among students. For courses in the engineering disciplines the laborations are important part that require access to experimental equipment and appear to be a major problem.

The course in basic digital electronics described in this paper is a part of a nation-wide initiative called *Engineer Online*. The objective is the have a full educational program in electrical engineering leading to the degree Bachelor in Science in Electrical Engineering (BScEE). In order to manage to develop a full program in short time several Swedish universities are cooperating in this work. Each university is responsible for developing and carry out two or three courses.

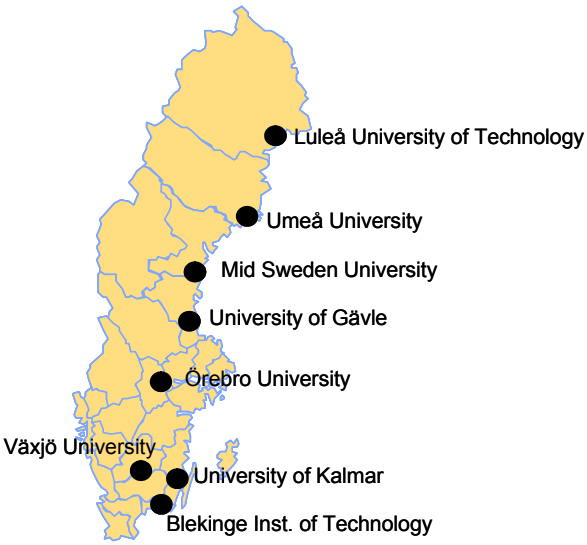

Fig. 1: Co-operating universities

For the course discussed in this paper we have the ambition to make it completely flexible in time and location. No activities are scheduled except for deadlines for handing in assignments and exams. The students can follow the course without having to travel to an university campus or a study centre. The course contents is well established by running it for many years as a campus course. The challenge is to transform it for distance learning with the goals setup for flexibility and the constraint on how many working hours could be spent on transforming it.

From Figure 2, it can be seen that there is a large difference in the student's age distribution between those enrolled in the campus course and those in the distance course. Slightly more than 80% of the campus students are between 20 and 25 years old. For the students in the distance course they are more evenly distributed in ages from 20 up to 40 years old. These numbers, based on statistics of our students, confirms the assumption that distance learning courses are attractive for adult students.

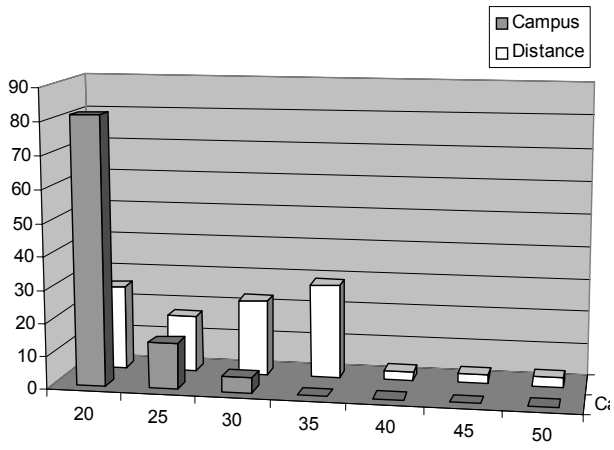

Fig. 2: Student's age distribution

This paper discusses how we organized flexible lectures and laborations with additional support for the students to actively follow the course. The outline for the rest of the paper is as follows. In Section 2 the overall organization of the course is presented. Section 3 discusses the web-based lectures and section 4 presents the role of the laborations and exercises. In section 5 we discuss the advantages and short-commings of our approach based on course evaluation questionnaires from the students.

II. ORGANIZATION OF THE COURSE

The organization of the course inherits the basic structure of the campus course with lectures, exercises, and laborations. The differences lies in the way the how they are carried out, the way communication with the students are made, and how examination is made. The key issue to address is to maintain clear and accurate communication with the students. In a campus course with direct face-to-face communication misunderstandings and ambiguous information are easily resolve while in distance learning this may lead to large damage and miscontent among the students.

The course is composed of eight elements which are all well-defined and specified by the following:

- Contents
- Learning goals; formulated as "*After completion of this element you should be able to ...*" with objectives formulated according to Bloom's taxanomy [1].
- References to recommended textbook reading and execersises
- Obligatory laborations for this element
- Examination for this element

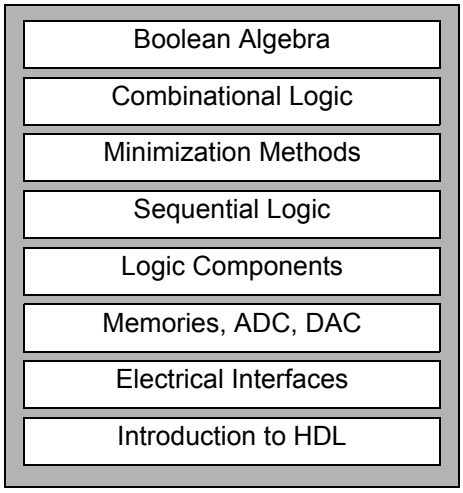

Fig. 3: Elements of the course

In order to stimulate the students to be active during the whole course period, we use *continuous examination* that has been shown to give good results [5]. This means that the examination of the course is evenly spread over the whole course period. The course examination is based on three written exams, denoted *T1-T3*, and three laborations, denoted *L1-L3*. The written exams are the basis for the student's grade and the laborations are obligatory but not graded. We view the laborations as an important method for learning and understanding the topic rather than a way for examination.

The course is web-based supporting all communication between the instructor and the students.

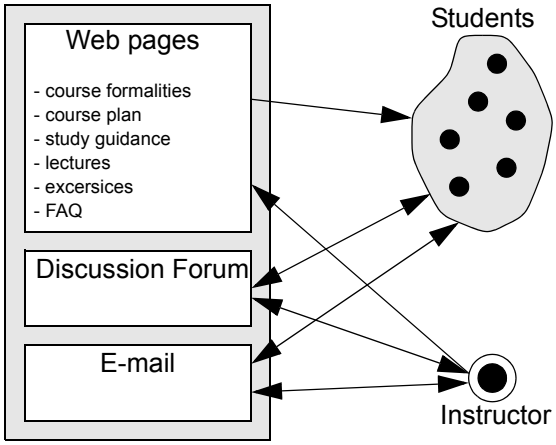

Fig. 4: Student - Instructor communication

The purpose of the web-pages is to house all information and documents needed to follow the course.

In communication with the instructor, the students are encouraged to use the discussion forum before using e-mail. Most questions are of general nature and are therefore of interest to the whole student group. In this way more active discussions among the students are promoted and the load on the instructor answering questions individually is reduced.

The course period started week 45 and ended week 3. In Figure 5 the student's activity, measured in number of

e-mails and posts in the forum, in communication using the discussion forum and e-mail is shown. The activity is quite evenly distributed over the whole period with the exception of week 52 during the Christmas holidays. The deadlines for handing in laboration reports and exams, indicated in Figure 5, are evenly distributed.

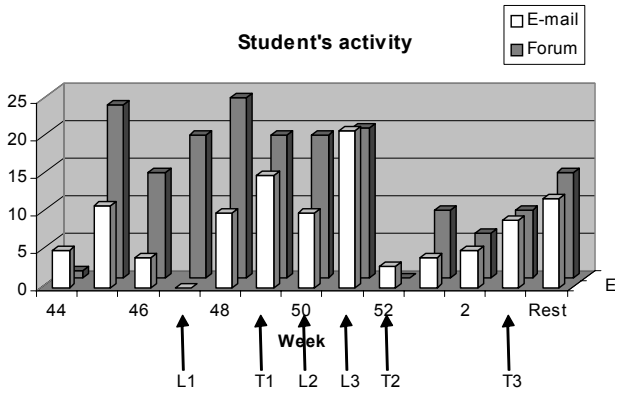

Fig. 5: Student activity time-line

III. LECTURES

The purpose of the lectures is the introduce the students to the various topics and point out the key issues to enable self studies. Most of the techniques and methods in digital electronics is very suitable to be illustrated graphically and therefore suitable as animated powerpoint presentations. Some examples are Karnaugh-maps, schematic diagrams, timing diagrams, and the operation of finite-state machines in state transition diagrams.

Teaching by lectures is the most common way in campus courses. For distance learning courses it is questionable whether it is the appropriate form or not. Video conference systems for lecturing is one commonly used approach that makes it possible for two-way communication during the lectures. This is a synchronous form that we do not find suitable since it is not flexible in time. It do also put high requirements on the student's Internet connections. Another form is video recorded lectures that can be distributed asynchronously via the Internet or mail. Producing live recording of lectures in a campus course with good quality is not straight-forward. The problem is that such recording contains scenes and sounds not relevant and moves the focus from the material to be presented. It is also difficult to incrementally update parts of the material.

We choose to base the lectures entirely on animated OH-presentations in Powerpoint. A speaker voice is added, which is the lecturers comments to the slides. The advantages are that the information can be focused, the material can easily be updated by replacing or adding slides. We have one lecture for each course element and each lecture is approximately 60 minutes each which is approximately the same length as for the campus course. The lectures are viewed in any web-browser using the *Flash* format [2], see Figure 6, that we found most efficient with respect to compression. The recorded material requires 136 kbytes per minute which gives a total of 62 Mbytes for the all lectures (7.5 hours). The material was produced by recording the powerpoint slideshow using Camtasia [3] that captures the screen resulting in a video sequence. At the same as the lecturers's voice is recorded. As a complement, the lectures were also distributed as ordinary handouts in pdf-format.

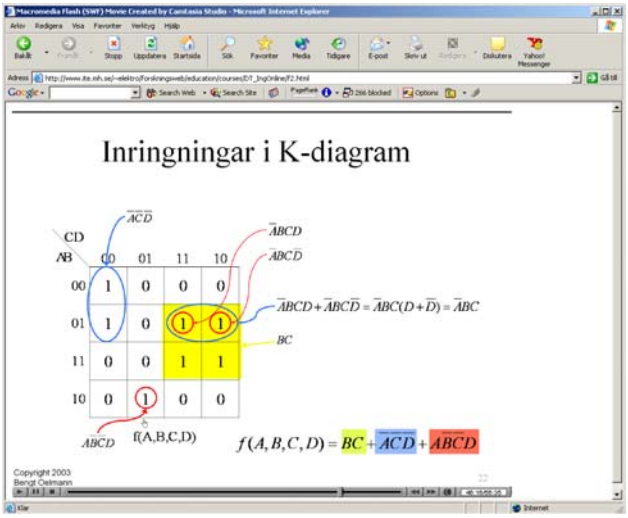

Fig. 6: Screen capture of animated lectures

IV. LABORATIONS AND EXCERSISES

In the engineering disciplines, laboration is an important part for learning the topic through hands-on experiences. This is however very difficult to accomplish in a distance course. One solution is to arrange one or two meetings on-campus when all laborations are carried out. This is obviously preventing many of the students to participate. Another way is to send out inexpensive lab-kits so that the labs can be done at home. The disadvantages here are that only very low-cost equipment can be distributed that is not adequate and therefore does not reflect the equipment normally available to engineers. We choose to use simulations as a substitute to laborations with physical devices and instruments. In a course in basic digital electronics we believe that for learning most of to topics this is sufficient. By considering that a digital designer uses exclusively CAD (Computer Aided Design) throughout the design process, makes this approach adequate.

Many free-of-charge CAD-tools with schematic editor and simulator are today available. Some textbooks come with student versions of professional tools that are in some way restricted. These are typically more than sufficient and gives the student the experience in using a professional tool. They are, however, quite complex and contain many functions not needed for the course which makes the threshold to learn how to use them unnecessarily high. We choose to use a tool, called Dsch2 [4], developed for educational purposes only which makes it easier to learn and use. In Figure 7 a screen capture of the tool is shown.

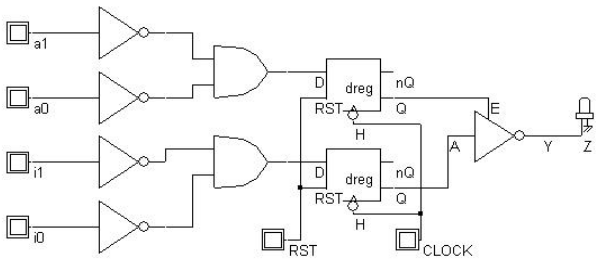

Fig. 7: Screen capture of Dsch2 schematic

The laborations have a great potential to be the part in the course where interactions between the instructor and students as well as interactions among the students that can support learning very well. Discussions in the forum about how to solve the problems can be freely discussed with many participants since the laborations are mandatory but not a part of the examination.

In an on-campus course often teacher-assistanced exercises are used to support students to learn solving problems. In the distance course we have simply published solutions to a number of problems from which the students can see how to proceed.

V. DISCUSSIONS

The development of Internet based learning enables many new possibilites for distance eduction. Software tools, such as WebCT, supporting the setup of web-based courses and inexpensive ways to produce video-based lextures are also available. Using some of these techniques may however require lots of resouces in order to develop the material. When transforming a campus course to a distance course it is important to identify the key issues that enable students to follow the course independently of location and time. As a developer of a distance course, the time spent on course development is often very limited. It is therefore important to focus on the key issues that support the students to study the topic more independetly than on-campus students. In the course discussed in this paper we have kept the basic structure from the campus course with lectures, execercises, and laborations. The lectures we consider to be one-way communicaton from the instructor to the students. Here the key issue is to present the central topics in a clear and precise way. The excercises with solutions shall through examples illustrate the methods of solving problems.

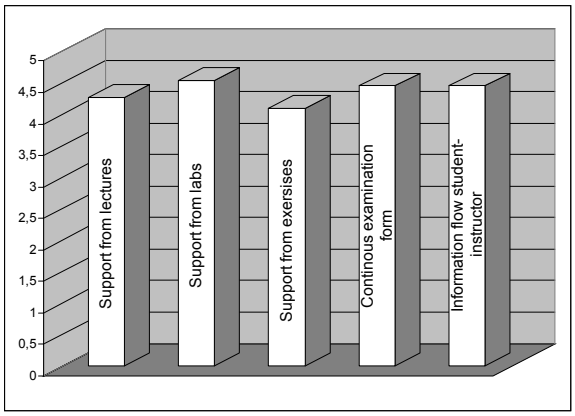

Fig. 8: Student's course evaluation

In Figure 8 part of the results from the course evaluation is shown, where the students have graded different aspects of the course with 5 as the most positive and 1 as the most negative grade respectively. In general the students had a more positive view on the course than students normally have on an on-campus course. In average the students found the labs to provide the best support for their studies. The excersices were found the be very useful but several commented that it was difficult to learn from written solutions alone. Animated solutions with speaker voice were therefore requested by the students. The instructor-student communication were found to be good and quick responds by the instructor was important.

The major part of the development time was needed for preparing the animated powerpoint presentations with speaker voice. At the end of the course (week 3) approximately 50% of the students had completed the course sucessfully. Many of those not completed the course still had to hand in laboration reports.

We have shown how an established on-campus course in digital electronics can be converted into a flexible distnace course using streaming media and simulation tools.

VI. ACKNOWLEDGEMENTS

The authors acknowledge the support of this work to the program coordinator Anders Nelsson at Blekinge Institute of Technology and Lars Logenius, Head of under-graduate studies at ITM, Mid Sweden University.

VII. REFERENCES

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