

Online Development of Digital Logic Design Course

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Abstract

Over the past few years, a shift to the use of multimedia in teaching is being implemented to enhance the learning process. This paper outlines the experience obtained through the development of digital design course to be taught online over the Internet. It discusses the advantages and disadvantages of these innovative learning strategies over the traditional chalkboard learning. This e-course has been in use since the completion of the development phase and is now in its second year of implementation. Initially, it was used entirely as supporting or supplementary material. Feedback taken from students indicated that the e-material enhanced their understanding of the course. Currently, it is being tested in the blended mode where selected material from the e-course is taught to students completely online.

1. Introduction

The Digital Logic Circuit Design course is the first course in the fundamentals of digital systems for the students majoring in electrical engineering. This is a core course and a pre-requisite for higher level courses in the areas of digital systems, digital communications and digital control. This course is offered every semester in the EE department at KFUPM with high student enrollment.

The objective of developing this online course was to provide an interactive, convenient, and self-paced, e-learning tool for teaching the fundamentals of Digital Logic Circuit Design.

Initially, the e-course was used entirely as supporting or supplementary material. Feedback taken from students indicated that the e-material enhanced their understanding of the course. Currently, it is being used in a blended mode where selected material from the e-course is taught to students completely online. A survey is conducted to get the feedback of students on the blended mode of learning.

2. Contents of the e-Course

The textbook [1] and syllabus used for the classical method of course delivery forms the basis of the material

covered in the e-course. It is based mostly on the lectures taught in the face-to-face classes with adaptations for an online course. Care was taken not to overwhelm the students with excessive course material while at the same time covering the course knowledge adequately. The e-course consists of 36 lectures which are divided into the following 9 modules:

1. Binary Number System
2. Boolean Algebra
3. Logic Circuits and IC's
4. The Karnaugh Map
5. NAND, NOR & XOR Gates
6. Combinational Circuits
7. Programmable Logic Devices
8. Sequential Circuits
9. Registers and Counters

The course material features interactive examples, graphics and animations with supporting speech. An automatic Text-to-Speech software tool was used to generate the speech files.

Each lecture includes several practice problems which form an integral part of the lecture. A student can try out these practice problems and get immediate feedback. Some lectures also feature interactive digital circuits that allow the student to run a circuit and check its functionality by changing the inputs in real time through "button switches". As the input switches are toggled, the change is reflected in the output according to the behavior of the circuit.

3. Development of the e-Course

The development of the e-course [2] went through several stages as described below:

3.1. Preparation of Course Contents

The course material was first prepared using Microsoft Office, MathType and Visio. The entire course was then developed for e-learning using Macromedia Authorware [3][4][5] as an authoring tool which allows the publishing of course lectures in HTML format for delivery over the internet. The development of the material was carried out in the following phases:

Phase I: Transfer of Course Material to Authorware

This involved preparation of course contents in electronic format (e.g. MS Word) especially tailored for online delivery. The prepared material was, then, transferred from MS Word or PDF format to Macromedia Authorware.

Phase II: Animations & Embedding of Speech Files

In this phase, animations were added and speech files were generated for each lecture. The speech files were, then, embedded in the Authorware files and synchronized with the flow of text and animations on each slide.

Phase III: Refinement of Lectures & Interactivity

In this important phase each lecture was reviewed by the team for improvement of the material in all its aspects and its overall presentation. The lectures were then modified based on the comments/suggestions made in the review. Interactive examples/circuits suggested for a lecture, as a result of the review, was also implemented.

Phase IV: Publishing of Lectures for WebCT

Each lecture was published in HTML format using the built-in publishing tool in Authorware. The published lectures were uploaded to the EE 200 course shell in WebCT and then hyper-linked and organized under modules. Other documents related to the course were also made available on the WebCT.

3.2. Generation of Speech Files

An Automatic Text-to-Speech [6] software tool was used to generate the speech files. This Automatic Text-to-Speech tool provides great flexibility in the creation and maintenance of speech files for lectures with speech embedded in them. It allows the speech files to be generated from text very easily. Any time a speech file needs to be changed only the text file is modified and a new speech file is created by the press of a few buttons.

3.3. Assessment and Feedback

For the purpose of student assessment, the online course features a set of quizzes and assignments. The type of questions that can be setup for quizzes and exams is limited. Some questions in quizzes and exams that require students to enter mathematical equations, design a circuit, etc. are not possible with the existing tools and hence cannot be offered online. Such quizzes and exams may have to be offered offline in the traditional manner.

3.4. Communications

The WebCT communication tools facilitate student-to-student cooperation, student-to-instructor interaction, and group discussions. Both synchronous and asynchronous communication tools, like Chat, White Board, Discussions, e-mail, etc. are available in WebCT and the same are utilized. Besides these tools, students can also contact their instructors by phone.

Contact information like email addresses, phone numbers of instructors, schedule of instructors' contact hours are posted on the website.

3.5. Management

The following management tools are available as built-in features under the WebCT platform and the same are utilized in the management of the e-course:

- Course Material Delivery Management
- Student Tracking Management
- Student Progress Management
- Technical and Accessibility Management

3.6. Interactivity and Multimedia features

Interactivity is a very important element of a good online course. Interactivity helps in better understanding of concepts and ideas. Well designed interactivity can arouse students' interest in the material and encourage active participation in learning online. The term, interactivity, describes the forms of communication that a medium supports enabling dialogue between the learner and the instructor and is an important attribute of technology-supported educational environments. The intelligence of the technology is used in place of the instructor and exchanges are made between the learner and the programmed instructional system. The interactions in electronic learning environments are able to enhance learning through the feedback they provide and the context and purpose they are able to encourage support [7].

With the above in mind, a number of interactive circuits were created which allow a student to interact with the circuit, change input values and watch how the output is affected. It must be noted that what can be demonstrated through interactive circuits and examples in the e-material is not possible at all in a traditional face-to-face class. This is a distinct advantage of online courses over the classical form. The following are some of the interactive circuits in the e-course:

- Digital Logic Gates
- Parity Error Detection System
- Full- and Half-adder circuits
- 4-bit binary Adder/Subtractor
- BCD Adder
- Multiplexer & Decoders
- Flip-flops
- Serial Adder
- Universal Shift Register
- Binary Counter with Parallel Load

It has also been found from student feedback that concepts that are difficult to understand in a face-to-face class or which take longer for an instructor to explain in the class are easily understood by way of interactive examples.

3.7. Interface

An effective use of multi-media rich e-learning material depends on an appropriate interface design to enable trouble free and easy access to these features [2] [8]. The interface design provides ease of navigation, a sense of human interaction, and responsiveness to the needs of learners studying in an information rich, self directed medium.

Each e-lecture has multimedia features and buttons for navigation through the material and a few special functions as mentioned below:

- **Previous and Next** slide buttons
These buttons allow navigation through the material one slide at a time.
- **Menu** button
Each lecture/session is divided into sub-topics which can be directly accessed through the Menu. Pressing the Menu button brings up the “Session Topics Menu”
- **Repeat Slide** button

This button allows the user to repeat the presentation on that slide.

- **Sound Off** (Check box button)
While the Sound Off feature is active the presentation of the material is speeded-up and sound is turned off. This button allows the user to view the material without sound if he so wishes. This is particularly useful for a quick review of the material when the user has already gone through the material once with all its multimedia features playing.
- **Pause** button
The Pause buttons allows the user to stop the presentation including speech on the slide at any time. The slide presentation can be resumed by clicking on the **Resume** button which is displayed when the **Pause** button is clicked.

4. Sample Screen-shots from the Online Course Materials

The screen shot shown in Fig. 1 taken from a lecture on (Number Systems) shows an animated example for the conversion of a decimal number to binary. The example proceeds in a step-by-step manner showing the different steps involved in the conversion process.

Number Systems EE 200 Lecture 2

Conversion from Decimal to Base r

Example 2: Convert 13.125_{10} to binary (base = 2)

$$\begin{array}{r} 13 \div 2 = 6 \text{ R } 1 \\ 6 \div 2 = 3 \text{ R } 0 \\ 3 \div 2 = 1 \text{ R } 1 \\ 1 \div 2 = 0 \text{ R } 1 \end{array}$$
 So, $13_{10} = 1101_2$

$$\begin{array}{l} 0.125 \times 2 = 0.25 \text{ R } 0 \\ 0.25 \times 2 = 0.5 \text{ R } 0 \\ 0.5 \times 2 = 1.0 \text{ R } 1 \end{array}$$
 So, $0.125 = 0001_2$

Therefore, $13.125_{10} = (1101.001)_2$

Slide Done | Slide 10 of 16 | Menu | Repeat Slide | Sound Off | Pause

Figure 1. Animated example for the conversion of Decimal numbers to binary

Figure 2 shows interactive circuits for Full-Adder and Half-Adder circuits. A student can try these circuits and check their functionality by changing the inputs in

real time through the “button switches” shown. As the input switches are toggled, the change is reflected in the output according to the behavior of the circuit.

Figure 3 demonstrates the concept of a simple parity error detection system through an interactive circuit,

which is not possible to show on the black board in a face-to-face class.

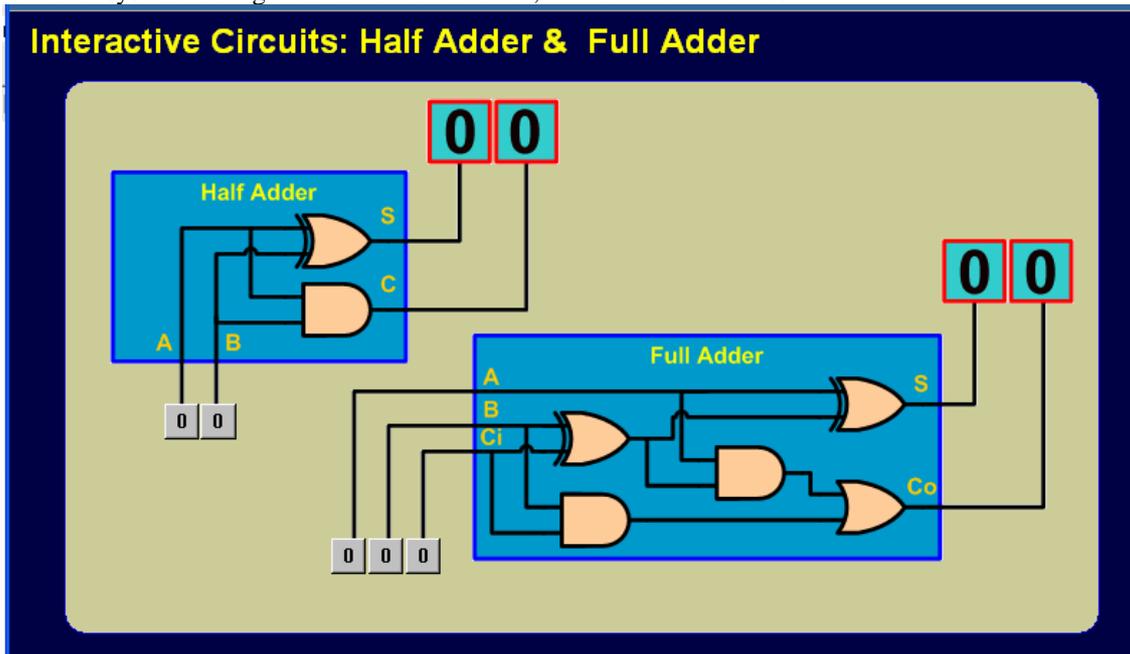


Figure 2. Interactive circuits for half adder and full adder

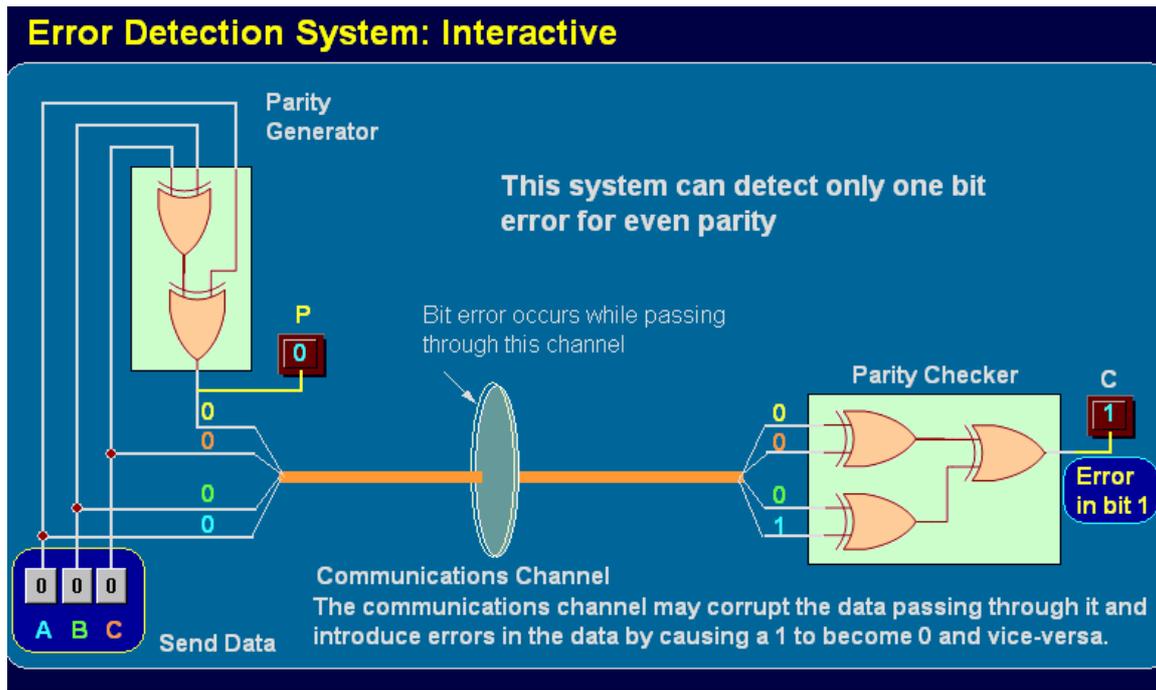


Figure 3. Interactive parity error detection system

5. Implementation

After the completion of the course development, the online course was offered initially as supplementary material for one semester. The objectives of offering the course as a supplementary material are to test the effectiveness of the online material and to get feedback from students. A further objective is to enable faculty members teaching the

course to become more familiar with the elements of the online course [5] [9].

Following this supplementary phase, the course was offered in a blended mode to allow parts of the course to be taught completely online. Based on feedback from the students and instructors, the entire course may be taught completely online in future.

Other online developed courses at the EE department have also been provided as supplementary

material. All students enrolled in these courses have been given access to the material hosted on WebCT as they are given free Internet accounts. Surveys have been conducted at the end of the semester to get students' feedback on the use of the online material in blended mode. The students were asked to choose an answer between A-F, according to how strongly they agree with the statement of the questions. The answers are shown in Figure 4. A total of 108 students participated in this survey.

Response to survey questions 1 through 5 reveal that students like to utilize the online course material as supplementary material because of the multimedia

features, animations, graphics and simulations used. However, there seems to be resistance on part of the students to the idea of replacing the traditional face-to-face classes with learning fully online.

A few courses are currently being offered in the blended mode in the Electrical Engineering department wherein selected online lectures from the material are taught completely online for a few weeks during the semester. No instructor-led lectures are given during these weeks. However, instructors and students meet once a week for a discussion and a quiz to assess student progress.

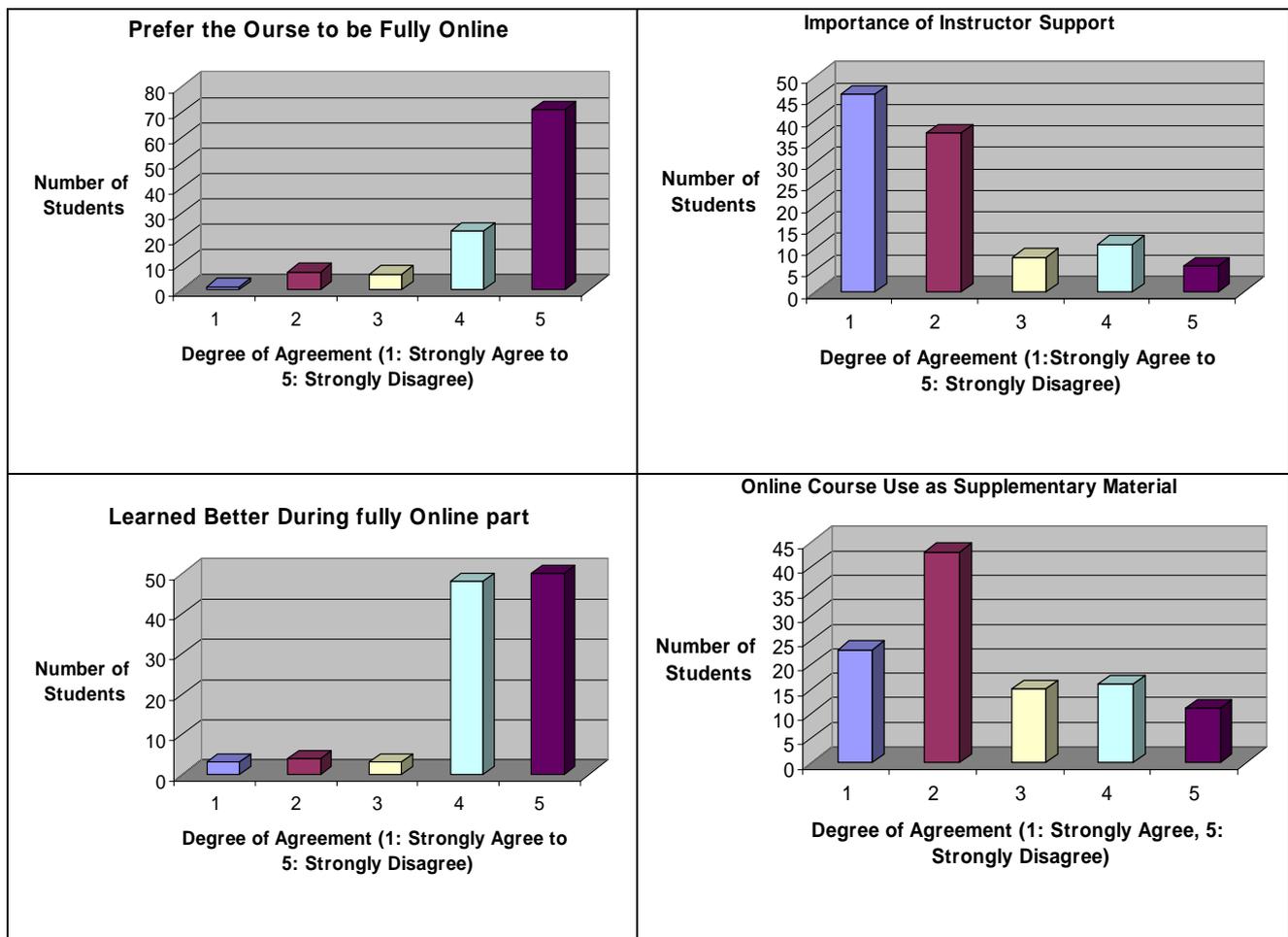


Figure 4. Survey of 108 students who took the course in blended mode

6. Conclusions & Recommendations

Online courses in the electrical engineering curriculum can enhance both the teaching and learning processes. In particular, students who have to be absent for some lectures can find means to make up these classes. Instructors can cover the entire material specified in the syllabus of the course with the help of online material. However, students have to be self-motivated for the program of online course to succeed. Survey of students indicated that at this level, students are not ready to receive their education completely online.

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