Application of a Learning Model in an Introduction to Digital Logic Course

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Abstract

During the 2003-2004 academic year, a general learning model is being employed at the School of Engineering at Vanderbilt University (VUSE) in the "Introduction to Digital Logic" course. This course is accompanied by a laboratory component. There are multiple sections offered in this course. This learning model is being applied to half of the sections. Students register for one of the offered "Introduction to Digital Logic" sections. Students have no knowledge that there are different modalities of instruction. This method assures a nearly random assignment to sections. The remaining sections will receive the traditional approach to instruction. The sections using the learning model receive instruction through a combination of lecturing, active learning exercises, collaborative learning exercises, and peer instruction exercises. In these sections, students are engaged in challenge projects and presentations. Instructors and teaching assistants are provided with special training workshops on techniques for incorporating lectures that have active, collaborative, and peer instruction exercises. The traditionally instructed sections primarily receive lecture-based instruction. The effectiveness of the learning model is measured through surveys collected from students, instructors, and teaching assistants. Throughout the course of the academic year, a comparative study is performed on the sessions employing the traditional instruction methods versus those employing instructional methods from a learning model. The study evaluates the students' course performance, attitude toward their instruction, retention, success rate, failure rate, and confidence levels of students in both the traditionally taught sections and the sections utilizing the learning model. The study also captures the instructors' and teaching assistants' responses to the effectiveness of both modes of instruction. This study provides strategies on how to maintain effective instruction while applying the learning model beyond this research study. Methods to apply sustainable instruction while utilizing the learning models are explored on other courses. This paper will present the underlying details of the learning model, and an analysis on the study performed during the 2003-2004 academic year.

Introduction

For many students, the Introduction to Digital Logic course serves as the first engineering course. During this crucial time in an engineering student's educational career, it is imperative to provide an environment that is learner centered, knowledge centered, assessment centered, and community centered[1]. An approach to providing this type of environment is captured in a general learning model. This learning model will feature a weekly learning session, structured collaborative laboratory sessions, and challenge projects. The Introduction to Digital Logic course consists of three lectures per week accompanied with a weekly three hour laboratory session.

Researchers conducting studies in engineering and science classrooms and laboratories have validated many of techniques that will be used in the general learning model. Many of these techniques extensively use a combination of lecturing, active learning exercises, collaborative learning exercises, and peer instruction. Some of the researchers compared students' performance and confidence levels in different learning environments.

In a benchmark paper, a longitudinal study of engineering student performance and retention was performed at North Carolina State University in the Department of Chemical Engineering [2, 3, 4, 5, 6]. In the study, a cohort of students took five chemical engineering courses taught by the same instructor in five consecutive semesters. There were more than 100 students in the cohort. For this study, the focus was placed on analyzing: (i.) the success and failure in the introductory course, (ii.) rural/urban differences, (iii.) gender differences in student performance and attitudes, (iv.) instructional methods and students responses to them, and (v.) comparisons with traditionally-taught students. Dr. Richard Felder and a group of researchers concluded that there were factors in a student's background that might be significant predictors of success or failure in the course, and by extension, in the chemical engineering curriculum[2]. Supportive evidence was provided for the geographical disparities [3]. Attention is given to some of the difficulties that women face in the engineering classes with suggestions to help alleviate some of the difficulties[4]. There were observations given that suggested that experimental instructional methods were effectively implemented and were well received by the students[5]. The methods that constituted the experimental instructional approach have been shown in the study to have positive effects on students' academic performance, motivation to learn, and attitudes toward their education and toward themselves[6]. While focusing on a single course, this research will involve a combination of some of the instruments studied by Dr. Felder and others.

Another important study an assessment of students' learning was performed on an introductory physics course at Harvard University by Dr. Eric Mazur after including a structured peer instruction component. There were more than 100 students in the course. Prior to the study, Dr. Mazur was looking for ways to focus the students' attention on the underlying concepts without sacrificing the students' ability to solve problems[7]. The result of this search was Peer Instruction, an effective method that teaches the conceptual underpinnings in introductory physics and leads to better student performance on conventional problems[7]. The students' learning was evaluated through two diagnostic tests: the Force Concept Inventory and the Mechanics Baseline Test[7]. The post-inventory scores after using Peer Instruction were greater than the pre-inventory score without Peer Instruction[7]. A portion of the proposed study will utilize concepts from the Peer Instruction method.

Methodology

This research involves conducting a comparative study of students enrolled in Vanderbilt University, School of Engineering (VUSE) in the course EECE 116 Digital Logic during the

2003-2004 academic year. EECE 116 Digital Logic is a course offered by the Department of Electrical Engineering and Computer Science. This course is a requirement for Electrical Engineering, Computer Engineering, and Computer Science majors. Electrical Engineering and Computer Engineering majors are scheduled to take the Digital Logic course during the spring of their freshman year. Computer Science majors are slated to take EECE 116 during the fall semester of their sophomore year. Students will pre-register for one of the offered EECE 116 Digital Logic sections. Students have no knowledge that there will be different modalities of instruction. This procedure is essentially a random assignment to sections. Half of the sections will use the experimental instruction techniques. The remaining sections will use the traditional approach to instruction. The sections with experimental instruction will receive instruction through a combination of lecturing, active learning exercises, collaborative learning exercises, and peer instruction exercises. In the experimental instruction sections, students will be engaged in challenge projects and presentations. Several training workshops will be provided to instructors and teaching assistants on techniques for incorporating lectures that have active, collaborative, and peer instruction exercises in them. The sections with traditional instruction will primarily receive lecture-based instruction. Surveys will be given to instructors and teaching assistants to aid in measuring the effectiveness of both modes of instruction.

Students in both the control and experimental group will be asked to complete the online version of the Index of Learning Styles Questionnaire developed by Ms. Barbara A. Soloman of the First-Year College, North Carolina State University, Raleigh, North Carolina and Dr. Richard M. Felder, Department of Chemical Engineering, North Carolina State University, Raleigh, North Carolina[8]. Students will be contacted via email about completing this inventory. Instructions and details about the inventory will be provided to the students at that time. Students will be asked to complete the online inventory, print out the results, and submit it anonymously. Surveys about students' prior laboratory experience, and students' evaluation of the course and of the laboratory experience will be distributed at the beginning and end of each semester. Formative surveys will be conducted as a means of constantly measuring the status of the instructional methods being employed.

During the laboratory session, students will present pre-laboratory and post-laboratory findings to the laboratory group. Students will be expected to keep two detailed laboratory notebooks: a bound notebook and a three-ring binder notebook. The bound laboratory notebooks will encourage students to record data and observations so that it can be later analyzed, evaluated, and interpreted for the laboratory report. The three-ring binder notebook will allow students to store handouts, graded pre-labs, and graded laboratory reports. Students will also be placed in teams to work on assigned challenge projects. Challenge projects will contain real world problems that will be analyzed by a team of students. A goal of the challenge projects is to incorporate design and problem solving strategies. The team will explain and submit reports from the project work. The project and presentation components will be used to help introduce students to an engineering environment with technical writing and presentations. The presentations and submission of reports will take place during the laboratory sessions. On the student evaluations of the course and of the laboratory, items about the laboratory notebook and challenge project presentations and reports will be present. Teams will be formed according to the results of the online version of the Index of Learning Styles Questionnaire.

Weekly learning sessions will be offered. These learning sessions will be structured, working sessions where students are given an opportunity to work problems. Students will be given opportunities to work problems individually and in teams. A goal of the learning session is to foster a peer instructed, collaborative learning environment with the instructor serving as the coach during the sessions. Instructors for the sessions will be provided techniques on the methods to manage a peer instructed, collaborative learning environment. The Peer Instruction method developed by Dr. Eric Mazur, a physics professor at Harvard University, will be used during the weekly learning sessions[7]. Peer instruction is one of the teaching approaches professors are using to engage students while inside and outside of the classroom. The basic goals of this team-based instruction are to exploit student interaction during the weekly learning sessions and focus students' attention on underlying concepts. To achieve these goals, learning session problems will be emailed to the students prior to the weekly learning session. At the beginning of the semester, outside reading assignments from the textbook will be provided to introduce all material. The textbook will serve as a reference and a study guide. Students will be encouraged to attempt to work the learning session problems before coming to the session. During the sessions, the focus will be on addressing potential difficulties, deepen understanding, building confidence, and including additional examples and problems. Attending the learning sessions will be optional. Students that attend at least three or more the learning sessions will be asked to complete a survey about the weekly learning sessions.

A comparative analysis will be performed on the traditional and the experimental methods of instruction. Surveys from students, instructors, and teaching assistants will be used in the analysis process. Students' individual responses will be kept confidential (i.e., no names or identifying information will be used). The study will evaluate the students' performance, attitude toward their instruction, retention, success rate, failure rate, and confidence levels of students in both the traditionally taught sections and the modified instruction sections. Through this study, strategies will be provided on how to maintain effective experimental instruction sections beyond this research study. Methods to apply sustainable experimental instruction on other courses will also be examined.

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