A Comparative Study of Traditional Instruction Versus Experimental Instruction

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Abstract

A comparative research study is being conducted at Vanderbilt University, School of Engineering (VUSE) in the "Introduction to Digital Logic" course during the 2003-2004 academic year. The course is accompanied by a laboratory component. This comparative study examines the traditional instructional approach and an experimental approach. The sections with experimental instruction receive instruction through a combination of lecturing, active learning exercises, collaborative learning exercises, and peer instruction exercises. The sections with traditional instruction primarily receive lecture-based instruction. Surveys from students, instructors, and teaching assistants provide a means of constantly measuring the effectiveness of the instructional method being employed. A comparative analysis is performed on the traditional and the experimental methods of instruction. The study evaluates 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 are provided on how to maintain effective experimental instruction sections beyond this research study. This paper presents the underlying methodologies of the study and some initial results obtained during the Fall semester 2003.

Introduction

Technology properly integrated into the traditional classroom and laboratory community has provided instructors with the flexibility to implement innovative methods of instruction and evaluation. These methods have led instructors to utilize teaching styles that incorporate many different learning style preferences. Students have a greater opportunity to interact with peers and the instructor in a technology enhanced environment.

There are several studies that have been conducted in engineering and science classrooms and laboratories using a combination of lecturing, active learning, collaborative learning, and peer instruction. Many of these studies have compared the performance of students taught in a traditional, lecture-based environment with those taught in an experimental instruction environment using a combination of one or more active learning techniques. Some of the studies are longitudinal in that it follows a cohort of students through their undergraduate engineering academic career, and other studies focus on a particular course over a period of time.

A longitudinal study of engineering students' performance and retention was performed at North Carolina State University in the Department of Chemical Engineering [1, 2, 3, 4, 5]. 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

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[1]. Supportive evidence was provided for the geographical disparities [2]. Attention is given to some of the difficulties that women face in the engineering classes with suggestions to help alleviate some of the difficulties [3]. There were observations given that suggested that experimental instructional methods were effectively implemented and were well received by the students [4]. 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 [5]. While focusing on a single course, this research involves a combination of some of the areas of interest studied by Dr. Felder and others.

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 [6]. 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 [6]. The students' learning was evaluated through two diagnostic tests: the Force Concept Inventory and the Mechanics Baseline Test [6]. The post-inventory scores after using Peer Instruction were greater than the pre-inventory score without Peer Instruction [6]. A portion of the proposed study utilizes 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 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 pre-registered for one of the offered EECE 116 Digital Logic sections. Students had no knowledge that there would be different modalities of instruction. This procedure is essentially a random assignment to sections. Half of the sections use the experimental instruction techniques. The remaining sections receive the traditional approach to instruction. The sections with experimental instruction receive instruction through a combination of lecturing, active learning exercises, collaborative learning exercises, and peer instruction exercises. In the experimental instruction sections, students are engaged in challenge projects and presentations. Several training workshops were 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 primarily receive lecture-based instruction. Surveys are 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 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 [7]. Students are contacted via email about completing this inventory. Instructions and details about the inventory are provided to the students at that time. Students 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 are distributed at the beginning and end of each semester. Formative surveys are conducted as a means of constantly measuring the status of the instructional methods being employed.

During the laboratory session, students present pre-laboratory and post-laboratory findings to the laboratory group. Students are expected to keep two detailed laboratory notebooks: a bound notebook and a three-ring binder notebook. The bound laboratory notebooks 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 allows students to store handouts, graded pre-labs, and graded laboratory reports. Students are placed in teams to work on assigned challenge projects. Challenge projects contain real world problems that are analyzed by a team of students. A goal of the challenge projects is to incorporate design and problem solving strategies. The team explains and submits reports from the project work. The project and presentation components are used to help introduce students to an engineering environment with technical writing and presentations. The presentations and submission of reports 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 are present. Teams are formed according to the results of the online version of the Index of Learning Styles Questionnaire.

Weekly learning sessions are offered. These learning sessions are structured, working sessions where students are given an opportunity to work problems. Students are 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 are 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, is used during the weekly learning sessions [6]. 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 are emailed to the students prior to the weekly learning session. At the beginning of the semester, outside reading assignments from the textbook are provided to introduce all material. The textbook serves as a reference and a study guide. Students are encouraged to attempt to work the learning session problems before coming to the session. During the sessions, the focus is on addressing potential difficulties, deepen understanding, building confidence, and including additional examples and problems. Attending the learning sessions is optional. Students that attend at least three or more of the learning sessions are asked to complete a survey about the weekly learning sessions.

A comparative analysis is performed on the traditional and the experimental methods of instruction. Surveys from students, instructors, and teaching assistants are used in the analysis process. Students' individual responses are kept confidential (i.e., no names or identifying information are used). The study evaluates 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 are provided on how to maintain effective experimental instruction sections beyond this research study. Methods to apply sustainable experimental instruction on other courses are also examined.

Conclusion

The initial indicators reveal that many students prefer receiving instruction in a collaborative environment. These results stem from written comments by participants in the weekly learning sessions. Students in regular attendance (three or more times) of the learning sessions performed above the class average on the class exams and the final exams. Through surveys measuring the confidence levels of students in both the experimental and traditional sections, students participating in the weekly learning sessions had a slightly higher confidence level when asked to problem solve, design circuits, and construct circuits. From the initial findings of the 2003 Fall semester, there has been more emphasis placed on integrating more opportunities to allow students to collaboratively and independently problem solve. From the Index of Learning Styles Questionnaire, trends and patterns of various learning style preferences are being examined to determine if there exist relationships.

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