Work in Progress - A Case Study of Perception and Learning Barriers of Students in Non-major Engineering Courses

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Abstract - **This paper presents the preliminary outcome of an ongoing study conducted on engineering students in a non-major course in electrical engineering. The goal of this study is to better understand the reasons for lower levels of performance in non-major engineering courses. We accomplish this by assessing student perceptions and attitudes towards learning, and measuring their understanding of core concepts related to a specific topic. Analyses of data collected to-date points towards some inherent flaws in common teaching methodology. We anticipate that this study will lead to a restructuring of these service courses to make them more relevant and conceptually grounded. Additionally, the development of reliable subject specific instruments as used in this study could be the basis for a broader framework which could be used for other engineering courses.**

Index Terms – service courses, student perceptions and attitudes, teaching methodology.

INTRODUCTION

Almost all engineering institutions offer the interdisciplinary coursework (*i.e.*, service courses offered to non-major engineering students), through their respective departments as prescribed in the ABET Criteria 2000 [1], [2]. Students in undergraduate engineering programs do not perform equally well in these service courses as they do in their major courses [3]. To better understand the reasons for this lower level of performance, we have embarked upon a longitudinal study in an electrical engineering (EE) course offered to non-EE majors. The objectives of this study are to assess student perceptions and attitudes towards learning a non-major engineering subject and also to measure their understanding of the subject's core concepts.

RESEARCH CONTEXT

The Electrical and Computer Engineering Department of Michigan State University (MSU) offers one service course for all non-EE majors covering basic concepts of circuits and instrumentation. The course has a heavy intake (80-90 students each semester) and is delivered in a traditional manner through lectures, labs and published notes. Like a typical service course, it is rotated amongst the department faculty on a 1-2 year cycle. Within this course, we have telescoped our study upon a singular topic: the Bipolar Junction Transistor (BJT). This is the most complex topic of the course as it requires a deep understanding of basic EE concepts. A mere 1.5 hour of lecture time dedicated to this topic makes it especially challenging for the instructor. The past data reflects poor understanding of the topic by the majority of students.

RESEARCH INSTRUMENTATION

There are two focus areas of this study that require a reliable and valid instrument for measurement and evaluation: 1) *Student perceptions and attitudes about the course;* 2) *Student understanding of the course content*. Literature review reveals a variety of standard instruments to measure student perceptions and attitudes toward learning in a course setting. Measurement and evaluation of understanding of the course content is a unique context that requires a context specific instrument. Such an instrument obviously is not readily available in the literature. It needs to be developed through indigenous effort and pilot tested to establish its validity and reliability before using it for the research. Two instruments have been developed after a thorough literature search and several consultation sessions with the education experts/subject specialists: a survey questionnaire for the whole class and a concept map for one-on-one sessions with a selected group of students [4]-[7].

SURVEY QUESTIONNAIRE

The survey questionnaire is comprised of 40 questions and is divided into four sections. Three of the sections measure student perceptions and attitudes on a Likert scale and were developed from the available literature. The fourth section is unique as it relates to the subject content and was developed by the researchers. It measures the understanding of the core concepts and their relationship to the selected topic (the BJT). The questions in this section are mostly in the form of simple numerical problems in two key categories: the *standard* or textbook type problems similar to those covered in the course, and the *inferential* problems requiring a step further in the understanding of core concepts and their interrelationship. To establish reliability and validity, the instrument was thoroughly reviewed and extensively pilot tested on a group of faculty experts and upper-level graduate students in EE. The instrument has been administered in two

978-1-4244-1970-8/08/$25.00 ©2008 IEEE

successive semesters (Spring 2007 (n=61) and Fall 2007 (n=47)).

I. Student Perceptions and Attitudes

Evaluation of the data reveals several interesting results. Some of the important ones are:

- The majority (89%) consider the course to be difficult. They are split on the issue of its usefulness (~ 50%).
- 68% devote three or fewer hours per week on self study for this 3 credit course.
- 89% consider the course lectures are monotonous while 77% perceive the course material as stimulating.
- 78% rely primarily on instructor notes to understand concepts. Only 32% feel that textbook enhance learning.
- Despite no exposure to online courses in engineering, the majority (93%) opine that the use of multimedia and web technologies would enhance learning.

II. Student Understanding of the Course Content

The statistical data represent a sharp contrast between the understanding of *standard* and *inferential* type problems. An average of 68% scored full marks in standard problems while only 15% could manage to score full marks in the inferential type problems. These results indicate that students appear to be focused on rote learning or on solving textbook problems, but face difficulties when asked to apply the concepts learned into somewhat newer contexts. It must be emphasized that the inferential problems were not extremely difficult, nor did they need any extra knowledge on the part of the students. All that was needed was an understanding of the conceptual underpinnings of the ideas and the ability to apply them.

CONCEPT MAPPING

To identify the nature of student understanding we conducted a qualitative analysis by working with a smaller representative sample of students. In this part of the study focus was not on their problem solving ability but rather on "mapping" their understanding of the relationships between key concepts. An important benefit of using concept mapping as an assessment method is its ability to detect or illustrate students' deep content understandings as well as their misconceptions when they create a personal explanation of content matter [7]. The expert map for the BJT topic was developed with the help of experienced faculty of the department. Several trial runs were conducted with the senior faculty experts to finalize the expert map before it was put to test.

The concept mapping sessions were administered one-on-one to twenty randomly selected students from five achievement groups based on academic performance (Excellent, above 90%; Good, 80-90%; Average, 70-80%; Fair, 60-70%; Poor, less than 60%). The interaction with the students during the interview sessions and study of the individual concept maps brought about some possible answers to lower performance in inferential type problems. The major findings are:

- Participants often lacked deep conceptual understanding of foundational ideas. Most of the student participants in the five achievement groups missed some important basic concepts in their concept maps. The missing blocks and the interconnection pattern in the concept map signify gaps in the learning of the BJT topic.
- Even, in cases where concepts were considered to be interrelated, the participants did so without sound reasoning. A participant from the "Average" group, for example, connected everything with almost every other thing. It indicates significant misconceptions of basic concepts and their interrelationship.

CONCLUSION AND FUTURE DIRECTIONS

This ongoing study presents the measurement and evaluation of student perceptions and attitudes towards learning, and understanding of course content related to a specific topic. This is accomplished through the development of two instruments: a survey questionnaire for the entire class and a concept map assignment for one-on-one interview sessions with a selected group of students.

The study completes the first step of an overall objective aimed at formulating a strategy for improving the teaching of service courses at the undergraduate level. The next step will involve some sort of intervention in the learning process to enhance students' understanding. This may require restructuring of the course content, development of some online modules and/or making optimal use of e-learning tools of the existing e-management system. We plan to implement these changes in a systematic manner and then conduct further studies in order to better understand student knowledge of core concepts. Finally, we suggest that the development of reliable and valid subject specific instruments (survey and concept map) as used in this study could be the basis for a broader framework which may be used for other engineering courses.

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