

AC 2009-2113: A PLAN TO IMPROVE STUDENT PREPARATION AND ENGAGEMENT IN ENGINEERING

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A plan to improve student preparation and engagement in engineering

Abstract

As in many engineering programs, the programs at the School of Engineering and Technology are concerned with improving our recruitment and retention, and have targeted action in two areas: pre-college programs (impacting recruitment) and the freshman introduction to engineering course (impacting retention) as part of our strategic plan for improvement. Inspired by a NAE-sponsored workshop held in Hampton University, entitled “Strengthening HBCU Engineering Education Research Capacity”, the engineering faculty hypothesized that our engineering program would be more successful if it paid greater attention to the learning styles of the target student populations in order to improve student preparation and engagement in engineering.

One option to engage students and provide more interactive learning opportunities is the use of case studies. This paper outlines how cases were introduced to the freshman course “Introduction to Engineering” and to a summer pre-college program, some results from the implementations, and discussion of the next planned steps.

This paper reviews the success of the use of case studies for the freshmen and pre-college students at Hampton University and discusses the next steps in our plan to improve preparation and engagement in our engineering students. Our goal is to improve retention and learning. And this effort integrates educational research and the classroom experience.

Introduction

The nation’s current and projected need for more Science, Technology, Engineering, and Math (STEM) workers, coupled with the chronically lagging participation of students from ethnically growing segments of the population, argue for policies and programs that will increase the pathways into engineering. Enhancing the curriculum is recognized to be an important way to improve overall diversity in engineering. Retooling curricula to prepare students for the innovation age requires them to explore open-ended problems, thereby acquiring higher-order cognitive and teamwork skills and equipping them with the tools they will need to become successful engineers. Past research has indicated that compared to traditional instructional methods, student-oriented instructional methods such as multi-media case studies that encourage student participation and active involvement in learning are better ways to accomplish these objectives¹. Many of the new skills needed to succeed in the innovation age can be achieved through the case study pedagogy. This pedagogy may be particularly effective for African-American students, who are inclined to prefer team-based interactive environments and whose learning styles might be different than those of traditional engineering students². The Laboratory for Innovative Technology and Engineering Education at Auburn University (LITEE)³ has developed a set of multi-media case studies that can be used in engineering program.

Chen⁴ believes that the student engagement begins with faculty engagement. The one-on-one interaction among faculty and individual students, both inside and outside the classroom, develop, facilitate, and sustain high levels of student engagement. In fall 2007, a NAE-sponsored workshop, entitled “Strengthening HBCU Engineering Education Research Capacity”, was held at the School of Engineering and Technology at Hampton University (HU). The theme of this workshop was the role of engagement and preparation in student learning. Engineering faculty members identified the needs of an effective learning community for our engineering students. Based upon this workshop, it is clear that an engineering program which pays greater attention to the learning styles of the target student populations may be more successful in increasing student learning.

This paper discusses plans to improve student preparation and engagement in Engineering. The plans include two projects to engage students in engineering: a summer pre-college program and the freshmen course “Introduction to Engineering”, both applying case studies to promote student learning.

Implementation of Case Studies in an Introduction to Engineering Course

This section discusses the results of implementation using case studies in the freshmen course EGR-101 Introduction to Engineering, which is required in the engineering and in the 5-year MBA program. The learning objectives for the course are that students should demonstrate the ability to define the engineering profession; to cite reasons why they have decided to become engineers; to identify and formulate problems with an engineering approach; to apply various mathematical methods for the solution of engineering problems; to write engineering reports on projects; to make an oral presentation on an engineering project; and to use ethics, societal, environmental and safety considerations to make engineering design decisions. The course content traditionally addresses engineering professions, engineering ethics, fundamentals of units and conversions, representation of data, statistics, energy, engineering design, and decision making process in a lecture format. This content is typically taught by the instructor using the blackboard/whiteboard and/or using an electronic presentation to enhance the explanation, followed by giving examples to clarify students’ understanding. A typical class consists of 30 freshmen, two thirds business majors and one third engineering majors.

Three case studies, Lorn Manufacturing, PowerTel and Chick-fil-A case studies, developed by LITEE³ team, are chosen to fit the course learning objectives. For example, the Lorn Manufacturing case study discusses engineering ethics, safety standards, and machine design issues, which reflect the learning objectives. The following introduces the case study implementation in one of the four sections of EGR 101 offered in Fall 2008.

The case study implementation was covered in four one-hour classes. In the first class, the instructor used PowerPoint slides, written by the instructor, to briefly introduce the three case studies the students were about to explore, and students were divided to teams with the assigned case studies and roles to defend. For example, in Chick-fil-A case study, Mike Erbrick, Director of Restaurant Information Systems at Chick-fil-A, was given the responsibility of converting the restaurant's point of sales (POS) systems from a proprietary EPROM based system to a newer system. This case study is a decision making process in selecting a new POS based on Windows

NT or Windows CE systems, or continuing using the current EPROM system. Three teams were assigned to defend the choice of Windows NT, Windows CE or the current EPROM system. The winning team was expected to possess the following properties: appropriate knowledge of operating systems, appropriate knowledge of the needs for Chick-fil-A company, and also good communication skills and teamwork spirits. The schedule for the remaining three classes and after-class activities were also addressed in the first class. Then the pretests and pre survey were given to students. After this first class, students should have a broad understanding of what the three case studies are about. Given a total of 18 students in this class and 3 case studies, there are 7 student teams, 2-3 teams working on one case study but assigned with different roles. In the second class session, students did the research on the assigned case studies in the computer laboratory, and the instructor was available for questions. In the third session, each team made a 6-8 min oral presentation on their findings and presented other teams their answers to the pretest questions, presumably correct answers. The students in the audience evaluated the oral presentations, and how well the speaker answered the questions, and then used their judgment to correct the pretest answers. This way students working on one case study could learn about other case studies based upon the oral presentations and the handouts (the PowerPoint slides written by the teams, and the pretest answered by the teams). As a result, every student should meet the same level of learning objective based upon the information they obtain from all the case studies. In the fourth session, students were given a post-activity survey, and quizzes on the case studies .

The qualitative analysis of Fall 2008 data (surveys and comments) was carried out by the LITEE team at Auburn University based on survey data taken at HU⁵. The report found that all of students indicated the case studies were a very positive experience in their learning of engineering principles. They found the case studies to be informative, interesting, and enjoyable. One student said, “If you can find more case studies like this online, it would be worthwhile to give them to us.” Another applauded the fact that the case studies merged engineering principles with information from other majors, such as business, architecture, and law. Their comments ranged from “overall it was a good experience” to “this is one of my most enjoyable classes.”

Based upon the pre and post surveys that address the perceptual measures (gain in higher-order cognitive skills, improvement in self-efficacy and improvement in team working skills), we find that both the experimental section (an EGR 101 section with case studies) and the control section (another EGR 101 section without case studies) perceived their higher-order cognitive skills at the end of the course to be lower than the levels anticipated at the beginning (see Table 1). However, whereas the drop was not statistically significant for the experimental section, the fall off was highly significant for the control section. On both the self-efficacy and team working dimensions, students in the experimental section perceived they had improved, although the mean increases were not statistically significant. In comparison, students in the control section perceived a significant decrease in self-efficacy and a substantial (though not statistically significant) decrease in team working skills.

In a survey of the instructor’s experiences to the LITEE team, the instructor wrote: “I believe the use of case studies has changed the students’ learning in my class. In my opinion, a business student who is destined to pursue money, master money, and make more money is hard to be fed with technical stuff. The business students take the engineering courses not because of their

interests, neither because they think the engineering courses would be useful in their future career, but because their curriculum requires them to. So changing their minds about engineering is a challenge for engineering faculty.” Based upon surveys, oral presentations, quiz, and comments from students, we believe the case studies attract students, and engage students in learning.

Table 1: Results of Perceptual Measures

Goals	Experimental Section (with case studies), n=18		Control Section (without case studies), n=23	
	Pre	Post	Pre	Post
1. Gain in Higher-order cognitive skills	3.7 (0.9)	3.4 (0.8)	3.7 (1)	3.0 (.8)***
2. Improvement in self-efficacy	3.5 (0.6)	3.7 (0.8)	3.6 (0.8)	3.1 (0.8)**
3. Improvement in team working skills	3.3 (0.5)	3.6 (0.9)	3.5 (1)	3.1 (0.9)

- Scale: 1 – Strongly disagree; 3 – Neither agree nor disagree; 5 – Strongly agree
- *** - difference between pre and post means significant at 0.01 level;
- ** - difference between pre and post means significant at 0.05 level

Implementation of a Case Study in a Summer Pre-College Program

The School of Engineering and Technology offered a one-week summer pre-college program entitled “The Business of Engineering” in summer 2007 and 2008. The program was designed to introduce engineering and engineering problem solving to rising high school seniors who had completed a three-week Summer Business Institute (SBI) as an introduction to business as part of the Leadership Education and Development Program in Business (or LEAD, see <http://www.leadprogram.org/> for additional information). Since the SBIs present case studies to students in the business context, the summer program team at Hampton decided to use a case approach to introduce engineering decision making for a problem with multiple (several non-technical) constraints.

Dr. Sid Credle, Dean of the School of Business and Dr. Eric Sheppard, Dean of the School of Engineering and Technology, developed the case study summarized below. Most of the student participants were new to the Hampton Roads area, so the case authors chose a topic that would introduce the region as the students access information from news articles and other sources. A description of the case and its application in the program follows.

Students in *The Business of Engineering* program (17 or 18 students) were given a design case study challenge of selecting the Hampton Roads transportation project that will best address current and future regional traffic needs. Students working in teams also wrote a short paper and presented their solutions while considering multi-modal options for the crossing, such as bus ways, high-occupancy vehicles (HOV), and passenger rail. Workshop sessions during the week provided the students with the key content to assist in their study. Team final reports considered

both technical and economic factors in making a recommendation, and energy issues were be included in the workshop discussions. Since one of the crossings, the Hampton Roads Bridge Tunnel is in sight of the Olin Engineering Building, students were able to make some traffic observations of their own.

Students were presented with background materials. The Hampton Roads Metropolitan Area consists of seven cities, many separated by water. North of the Hampton Roads waterway are Hampton and Newport News and south of the waterway are Chesapeake, Norfolk, Portsmouth, Suffolk, and Virginia Beach. Daily commuting between the north and south sides is heavy and limited to water crossings, so traffic is a key concern for everyday life as well as for evacuation situations. The crossing options are complicated by the fact that the port of Norfolk is a major commercial port and that there are major Navy and shipbuilding facilities in the area. At present, there are three crossings, two bridge-tunnels and one bridge. Ferry service was discontinued years ago.

There have been several studies of the traffic issues in Hampton Roads and there is a recommended solution for a third submerged highway tunnel, although this recommendation has not yet been implemented. Note that all groups in both years recommended mass transportation as at least part of the solution to the traffic issues.

Students worked in teams representing tourism, shipping, commuters, and the general public. The case study presentations were judged by a panel of professionals at Hampton University including the Principal Investigators, faculty from engineering and business, and University administrators.

This case study was well received by the 2007 participants as well as the 2008 group. The objectives of the program were met: student responses indicated that they were both engaged (they liked the case work and it involved engineering concepts) and felt that the project was relevant to their future studies (regardless of their intended major). Students also noted that the one-week format did not give them much time to work on the case or to do enough research on cost and other issues relevant to the solution. The summer program team is considering changes for summer 2009 that include lengthening to two weeks and changing the aim to rising high school sophomores.

Discussion

Two experiences with the use of case-studies in presenting engineering and engineering topics have initially indicated success in engaging students and presenting the learning objectives. The authors propose to continue to develop the implementation of case studies in the pre-college and freshman year course and to explore the use of cases in higher level courses and in our introductory programming course.

Clearly, there is evidence that case studies have the potential to better engage students and get across basic engineering concepts. Cases allow students to learn more interactively by “doing” as they take on guided engineering challenges in contrast to learning by being told about various

engineering approaches to problems. Our next step is to consider how to better tailor the guided cases to learning objectives and student needs.

The authors have discussed their experiences and note that there are two sometimes opposing issues in case design: the level of accessibility to introductory-level students and technical rigor. While published cases, such as those available from LITEE, may be more accessible to faculty members, since they have been written and tested and relevant technical learning objectives may be clearly outlined, care must be taken to ensure that they engage students based on their majors and interests. Cases produced by the engineering programs may address student interest and local topics but are not tested and some work is required to ensure that technical rigor is included. The authors suggest a two-level approach to case use that would address these issues:

1. Use of published case studies in introductory and higher level courses
2. Use of cases locally produced by faculty members in the pre-college program and as the initial case in the introduction to engineering course

The authors also propose a third more accessible type of case study that goes one step beyond giving students a chance to experience how engineers solve problems. Cases locally produced by students supervised by faculty members as alternatives in the pre-college program and introduction to engineering course would give these introductory-level students an opportunity to work in a guided environment on problems that advanced students work on (in fact they will be working on similar problems in a few years). Projects will come from senior design courses as well as team IEEE student chapter projects and advanced students participating in case writing will also learn with more depth.

These experiences will be shared with other engineering faculty members and are the first activities in creating a more interactive, engaging curriculum at Hampton University.

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