LITEE Special

Implementation of Case Studies in an Introduction to Engineering Course for " LITEE National Dissemination Grant Competition"

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Abstract

This paper discusses the results from the years 2008 and the 2009 of implementing the Laboratory for Innovative Technology and Engineering Education (LITEE) case studies in an engineering class at Hampton University (HU), a HBCU. Questionnaires were administered at the conclusion of the experiment. The goal of this research is to investigate the relevance of case studies and achievement of student learning outcomes: improving team working skills, improving their higher-order cognitive skills, and showing positive attitudes in engineering. Analysis of the student responses show that the students at Hampton University perceived a modest achievement in the three goals (above the average achievement). However, the students perceived the achievement in the higher-order cognitive skills and positive attitude dimensions at the end of the case study implementation to be lower than the levels anticipated at the beginning. The qualitative results show the need for incorporating multi-media case studies in engineering curriculum. To make the investigation of the impact of the multimedia case study on achieving the students learning outcomes a real research, it is suggested that the experimental section and the control section be coordinated and carefully designed for the comparison purpose.

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. 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 objectives (Mbarika, Sankar, & Raju, 2003; Boykin et al., 2005). This paper is an effort to fulfill the requirements of the "LITEE National Dissemination Grant Competition, Sponsored by NSF DUE # 0442531".

Since 2007, the school of Engineering and Technology at Hampton University (HU), a HBCU, has perceived the need to retool curricula and prepare students for the innovation age that requires them to explore open-ended problems, thereby acquiring higher-order cognitive and teamwork skills. Including the multi-media case studies in the introductory engineering course is a part of plan of actions to achieve better student learning outcomes. Each semester at HU, *Introduction to Engineering* is offered to students from the School of Engineering and Technology and the School of Business. The business students take this course with weaker mathematics prerequisites, and have less interest in engineering than the engineering students. Because of this, a concern about the necessity of separating the business students from the engineering students arises. Therefore, the case study would be a more attractive and a more efficient tool to assess student learning than just teaching them in a regular lecture-based way.

Implementation of Case Studies

This section discusses the results of implementation using case studies in the freshmen course EGR-101 "Introduction to Engineering" class, which is required in the engineering program and also in the five-year MBA program. The learning objectives for the course are that students should be able to demonstrate the ability to define the engineering profession, cite reasons why they have decided to become engineers, identify and formulate problems with an engineering approach, apply various mathematical methods for the solution of engineering problems, write engineering reports on projects,make an oral presentation on an engineering project, and use ethics, as well as 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 processes 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 section consists of 30 freshmen, two- thirds being business majors and one-third being engineering majors.

Three case studies developed by LITEE team (the Lorn Manufacturing, STL-51 Challenger, and Chick-fil-A case studies), are chosen to fit the course learning objectives. Specifically, the Lorn Manufacturing case study discusses engineering ethics, safety standards, and machine design issues. The STL-51 Challenger case study covers engineering design issues, engineering ethics, and the decision-making process. The Chick-fil-A case study also covers the decision-making process, as well as the operating system, which reflects the learning objectives. Two sections of EGR 101 were compared: a control section (without a case study) and an experimental section (with a case study). The two-semester data (fall of 2008 and fall of 2009) were analyzed and compared here. The same teacher taught the experimental section both in the fall of 2008 and the fall of 2009, while different teachers taught the control section. The 2009 case studies were carried out quite similarly to the year 2008. The differences are that there were two students as outside observers to observe students' oral presentations in 2009, and the pre-survey was given at the first class of case study (that is, during the middle of semester) in 2008, while it was given during the first few weeks in 2009.

The following gives a generic description of case study implementation in 2008 and 2009. The case study in the experimental section was carried out in five 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 were given roles to defend. For example, in the 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 the 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. After this first class, students should have a broad understanding of what the three case studies are about. Given a total of three case studies, there were seven student teams, two to three 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 remaining three sessions, each team made a six to eight minute 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, how well the speaker answered the questions, and used their judgment to correct the pretest answers. This way the students, even working on their own case study, could have further understanding about all the 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 obtained from all the case studies. Then students answered the post survey at the end. The pre survey and post survey can be found on the LITEE website [Survey].

The qualitative and quantitative analysis of the fall 2008 data were carried out by the LITEE team. The results were shown in the 2009 ASEE paper (Le & Sheppard, 2009). The qualitative analysis was done based on a short open-ended paragraph written by students. We found that all of the students indicated that using the case studies was 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."

The qualitative analysis of the fall 2009 data was carried out at HU based upon the descriptive answers to post-survey questions. To the post -survey question: "what part of the is course did you find to be the most interesting",8out of 18 students explicitly pointed out the case study, one student said "the parts that featured real life engineering concepts", six answers were N/As, and two responded with "None". Two junior students as the observers of case studies implementation applauded the case studies and said they were "envious" of the students who had a chance to experience case studies. They wrote:

> "Overall, the students appear to have benefited from the experience. It is worth noting that later presentations were generally of higher quality than the earlier presentations. This can most likely be attributed to the fact that those who presented later were able to use criticisms of earlier presentations to their advantage. Also, those who presented later benefited from having more time to prepare. The students in the audience were remarkably active during discussion segments, indicating that the case studies were at least engaging if not interesting. The discussion segments also allowed students to continue to display logic and reasoning skills even when they weren't presenting. Based on ap-

Goals	2008Fall Experimental Section (with case studies), N=18		2008Fall Control Section (without case studies), n=23		2009Fall Experimental Section (with case studies), n=18 valid out of 24 students		2009Fall Control Section (without case studies), n=17 valid out of 27 students	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1. Gain in Higher-order cognitive skills (Q15, 16,17,18,33)	3.69 (0.9)	3.37 (1.0)	3.68 (1.1)	2.92 (1.1)	4.01 (1.0)	3.37 (0.9)	4.01 (0.9)	3.57 (0.7)
2. Improvement in team working skills (Q26,27,28,29,30)	3.35 (0.7)	3.53 (1.0)	3.54 (1.1)	3.09 (1.1)	3.94 (1.0)	3.30 (1.0)	3.88 (0.9)	3.66 (0.7)
3. Improvement in positive attitudes (Q20,21,22,23,24)	3.37(0.9)	3.30 (0.9)	3.42(1.1)	3.11 (1.1)	3.89 (0.8)	3.22 (1.0)	3.71 (1)	3.48 (0.9)

- Scale: 1 – Strongly disagree; 3 – Neither agree nor disagree; 5 – Strongly agree

Table 1: Results of Perceptual Measures in 2008 and 2009: Mean and Standard Deviation

parent student enthusiasm alone, it would seem that the case study project would be valuable as a permanent addition to the curriculum."

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- work skills), we find that both the experimental section (a EGR 101 section with case studies) and the control section (another EGR 101 section without case studies) perceived the achievement in the higher-order cognitive skills and positive attitude dimensions at the end of the case study implementation to be lower than the levels anticipated at the beginning (see Table 1). The anticipated levels of the three goals in 2009 are higher than those in the 2008 data. Overall, it appears that students in the control section responded more favorably to the course experience than students in the experimental section in 2009, while students responded more favorably in the 2008 experimental section.

For the 2009 data, we also analyzed the impact of genders and disciplines on the perceptual measures (see Table 2 and Table 3). In the experimental section shown in Table 2,

Goals	2009Fall Experimental Section (with case studies), # male = 11		2009Fall Experimental Section (with case studies), # female = 7		2009Fall Experimental Section (with case studies), # Engineering = 9		2009Fall Experimental Section (with case studies), # Non Engineering = 9	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1. Gain in Higher-order cognitive skills	3.93 (0.9)	3.42 (1.0)	4.11(1.1)	3.28 (1.1)	4.03 (1.0)	3.37 (0.9)	3.98(1)	3.37 (.8)
2. Improvement in team working skills	3.89 (0.7)	3.49(1.0)	4,02 (1.1)	3.00 (1.1)	3.86 (1.0)	3.11 (1.0)	4.02 (0.8)	3.48 (0.8)
3. Improvement in positive attitudes	3.84(0.9)	3.45 (0.9)	3.95(1.1)	2.85 (1.1)	3.87 (0.8)	3.24 (1.0)	3.90(1)	3.20(0.9)

Table 2: Results of Perceptual Measures in 2009 experimental section related to genders and disciplines: Mean and Standard Deviation

Goals	2009Fall Control Section (without case studies), # male = 10		2009Fall Control Section (without case studies), # female = 7		2009Fall Control Section (without case studies), # Engineering = 7		2009Fall Control Section (without case studies), # Non Engineering = 10	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1. Gain in Higher-order cognitive skills	3.95 (0.9)	3.65 (0.8)	4.09(0.8)	3.45 (0.6)	4.31 (0.6)	3.86 (0.8)	3.80(1.1)	3.37 (0.7)
2. Improvement in team working skills	3.92 (0.7)	3.68(0.8)	3.82 (0.8)	3.62 (0.6)	4.42 (0.5)	3.91 (0.8)	3.50 (0.9)	3.48 (0.6)
3. Improvement in positive attitudes	3.70(0.9)	3.68 (0.8)	3.73(1.0)	3.19 (1.0)	3.92 (0.9)	3.76 (0.8)	3.56(1.1)	3.28(1.0)

Table 3: Results of Perceptual Measures in 2009 control section related to races and disciplines

male students responded more favorably to the course experience than the female students in all three goals. All the differences were contrary to the logical direction. By the end of the course perceived cognitive gain, team-working skills gain, and the positive attitude gain decreased by 0.51, 0.40, and 0.39, respectively on average in male students. This is compared to a decrease by 0.83, 1.02, and 1.10, respectively in female students. Overall, the female students have higher expectations than the male students, and feel more modest after the case study experience. As far as the discipline is concerned, all the mean differences were still contrary to the logical direction. In addition, disciplinary differences do not make a difference in the cognitive gain and positive attitude gain. However, the non-engineering majors responded more favorably in the team-working experience than the engineering majors. Specifically, the team-work skills improvement decreased by 0.54 in the non-engineering majors, compared to a drop by 0.75 in the engineering majors.

In the Control section shown in Table 3, male students responded more favorably to the course experience than the female students in all three goals. All the differences were contrary to the logical direction. By the end of the course, perceived cognitive gain, team work skills gain, and the positive attitude gain decreased by 0.30, 0.24, and 0.02, respectively on average in male students. This is compared to a decrease by 0.64, 0.2, and 0.54, respectively in female students. Higher expectation from the female students is not obvious. However, female students still feel less improvement than male students at the end of the semester. As far as the discipline is concerned, all the mean differences were still contrary to the logical direction. However, disciplinary differences do make a difference in the three categories. The engineering majors have higher expectations at the beginning of the semester and responded more favorably in the three categories than the non-engineering majors. Specifically, by the end of the course perceived cognitive gain, team working gain, and the positive attitude gain decreased by 0.45, 0.51, and 0.16, respectively on average in engineering majors, compared to a decrease by 0.43, 0.02, and 0.28, respectively in non-engineering students.

Discussions and Conclusions

The 2008 and 2009 data provide findings for future study on the evaluation of case study impacts.

First, the findings suggest that the control section and the experimental section should be more carefully constructed for the comparison purpose in the future. How did the control section teach engineering ethics, engineering design, etc that was covered in case studies? It is possible that students were more excited about the lecture-based ethics related examples in 2009 than they were in 2008. The experience of the senior faculty in the control section may also be a factor of positive students' responses. Nevertheless, the control section should be carefully designed and taught to avoid comparing apples with oranges.

Secondly, the way to present the survey should be the same in both sections. Were students given the same amount of time to answer the survey in both sections? How would students know if the survey would affect the grade, etc? To avoid this, we suggest trying an online survey for future study.

Thirdly, the findings suggest that the samples in both sections be as complete as possible. What happened to the invalid data (missing pre-or post- survey) in the 2009 control section? Having all the students do the survey is critical. In this sense, we suggest that giving students credits for participation of survey in the future.

Fourthly, the findings from quantitative data (students' answers to multiple choice questions in the survey) indicated, the students' perceptions of their improvement in terms of higher order cognitive skills, and positive attitude dimensions were lower than expected. However the qualitative data indicates that the students favor the case studies and the two observers even suggested the case study as " a permanent addition to the curriculum". The 2008 qualitative data is based upon the students' one paragraph description about the course at the end of the semester and the students' answers to the description questions in the post-survey. In 2009, the qualitative data is based upon students' answers to the description questions in the post-survey and also the written perceptions about the course from the two student observers.To make the research comprehensive, we believe the qualitative analysis is a good supplement to the quantitative analysis especially when the findings from the quantitative data are contradictory to those from the quantitative data. We also believe that quantitative and qualitative experts should be of great help to better understand the students' perceptions. Junior or senior students as the classroom observers could also give us another dimension of students' perceptions because they took the introductory of engineering class two or three years ago. They could give us their perceptions of this course by comparing what they observe from the current course and what they experienced in this course three years ago.

Next, we investigated the impacts of genders and disciplines on the perceptual measures. Overall, the female students are more critical than the male students: they either have higher expectations than the male students or feel less improvement than the male students. In the control section, engineering majors have higher expectations than non engineering majors. However, this trend is not obvious in the experimental section. This perception might be because the control section is taught by the Chair of the Department of Engineering and the high expectations from engineering majors may come from the high expectations on their majoring program. In this sense, the pre-survey to measure students' expectations might not be necessary in future research because the expectations might reflect students' perceptions about the teacher, the major program or otherfactors.

In conclusion, the qualitative results show the need for incorporating multi-media case studies in engineering curriculum. The students perceived the achievement in the higher-order cognitive skills and positive attitude dimensions at the end of the case study implementation to be lower than the levels anticipated at the beginning. The anticipated levels of the three goals in 2009 are higher than those in the 2008 data. Overall it appears that students in the control section responded more favorably to the course experience than students in experimental section in 2009, while students responded more favorably in the 2008 experimental section. To make the investigation of the impact of the multimedia case study on achieving the students learning outcomes a real research, the experimental section and the control section must be coordinated and carefully designed for the comparison purpose.

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