

Incorporating a Real World Case Study into a Senior Construction Engineering Course

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INTRODUCTION

The industry demand for students with adequate problem solving and business skills is increasing. To better prepare students for the challenges of the business world, the Accreditation Board for Engineering Education (ABET) has defined a set of accreditation criteria (3a-k) which identify 11 outcomes expected of engineering graduates.

Previous studies have addressed the importance of case study in enhancing students' learning (e.g. Sankar et al., 1995; Raju and Sankar, 1999, Sankar and Raju, 2003; Mehta et al., 2007). However, little empirical investigation has been conducted to assess the effectiveness of cases in improving students' learning. To help students meet the expectation the Laboratory for Innovative Technology and Engineering Education (LITEE) team at Auburn University worked with industrial partners to develop a series of multimedia case studies under NSF support #0442531. These case studies help students visualize the real world problems and play the roles of concerned engineers and managers. Students work in teams and present solutions to the posed problem, analyze their solution and defend their rationales.

LITERATURE REVIEW

Participation of undergraduate students in hands-on research has been found to be significantly effective to encourage students to pursue advanced degrees and careers in science, technology, engineering, and mathematics fields (STEM) (Russell et al., 2007). In addition, it has been argued by several researchers that hands-on research increase understanding, confidence, and awareness (Seymour et al., 2004; Bauer and Bennett, 2003; Lopatto, 2004; and Gregerman, 2003). They also showed that inculcation of enthusiasm is the key to encourage students toward STEM; therefore greater attention should be given to fostering STEM interests of elementary, middle and high school students and providing undergraduate research opportunity for collegiate freshmen and sophomores (Hunter, et al., 2007, Bauer and Bennett, 2008).

Significant emphasis has been placed by both educators and practitioners on enhancing students' decision-making skills and higher-level cognitive skills to improve their performance in the real world work environment. Therefore, many educators strived to provide students with necessary education to become qualified managers (King, 2000). Students benefit from tackling real world problems by working on problems that require the synthesis of skills that they have acquired and refined during their graduate studies (Sankar and Raju, 2006).

RESEARCH MODEL AND HYPOTHESES

This section begins with the background that motivated an interdisciplinary program to solve real-world problem. The fundamental purpose is to place the students in the role of consultants to identify and solve the real-world problems. Care is taken to ensure that problems require an integration and synthesis of skills to be solved. The case "Mauritius Auditorium Design" was selected to be incorporated to the Construction Project course at North Carolina A&T State University.

To test if students' learning outcomes have been improved the following hypotheses have been developed:

- H₁: Using case study will significantly improve students' higher-order cognitive domain of learning.
- H₂: Using case study will significantly improve students' ease of learning subject matter.
- H₃: Using case study will significantly improve students' self-efficacy.
- H₄: Using case study will significantly improve students' team working.
- H₅: Using case study will significantly improve students' communication skills.

METHODOLOGY

This section of the paper describes the survey and survey results. The case study was assigned as part of the term project for senior students in the Construction Project Course. Students were teamed up in groups of three. Teams were provided with the information about

ABSTRACT

This paper investigates the effect of bringing real world case studies on college students' self efficacy, their confidence, and their motivation toward an engineering field. It was found that working with real cases increases student's motivation and maximizes their learning by becoming personally committed to course and program goals. As a result of trying to address the problem statement and analyze the assigned case, students will be inspired to learn the theory and relate the theory to the practice. It was also found that the learning process will be facilitated by students feeling a need to learn more about their subject to be able to tackle real world's problems.

Keywords: Self-Efficacy, Case study, Cognitive skills, Teamwork

Construct	Items
Higher-order cognitive domain of learning	Instructional materials improved my problem solving skills and helped me to identify engineering tools that will assist me in decision-making, how to inter-relate important topics and ideas, how to identify various alternatives/solutions to a problem, how to sort relevant from irrelevant facts.
Self-efficacy	This engineering course improved my confidence in applying Engineering concepts to real situations, made my learning easier, emotionally engaged me in learning the course topics, increased my self-confidence; helped me achieve a sense of accomplishment in learning; helped me assume a greater responsibility for personal learning.
Ease of learning subject-matter	I get frustrated going over Engineering tests in class, I am under stress during Engineering classes, and Learning Engineering requires a great deal of discipline.
Impact on team working	The instructional materials helped me improve my team-building and interpersonal skills, listen carefully to other's statements and ideas, arrive at decisions based on consensus building, share ideas with others, enhanced my interactions with my classmates.
Communication skills	My writing skills improved, My presentation skills improved, My informal communication skills improved.

Table 1: Constructs and items used to measure learning driven factor

Mauritius Auditorium case study. Students were asked to conduct the first assignment from the material covered in the case study.

Case Description

The case "Mauritius Auditorium Design Case Study" focuses on an acoustical design of the polyvalent hall at the Swami Vivekananda International Convention Center on the island of Mauritius. The multi-use hall was praised as a "fabulous building and quite an achievement" after successfully hosting a United Nations conference without any acoustical problems. Later, as a band rehearsed for the building's first rock concert, the sound quality fell severely short of expectations. A problem arose with the loud music, requiring a reconsideration of the hall's design before it could provide satisfactory acoustics for any similar events. The case was selected since it was related to the course (construction engineering). The case learning objectives were as follows:

1. To identify the performance of teams in a real-world situation and thereby learn how to apply the theories learned to actual situations.
2. Students learn about the importance of acoustics in designing a large multi-purpose hall.
3. Differentiate between alternate methods to fix

the acoustic problem.

Students were working on teams to provide their solution to resolve the problem. The teams defending the alternatives have to use both technical and non-technical (costs, risks, ethics) issues in their arguments. The teams performed the following tasks:

- Team A: Defend the recommendation to implement the Second Alternative – Newtex.
- Team B: Defend the recommendation to implement the Third Alternative – Use of Anu-tone (wood wool product).
- Team C: Defend the recommendation to implement the Fourth Alternative – Use of cellulose spray (K-13).
- Team D: Represent the team of Chuttur & Partners Limited and decide on the specific alternative that will be implemented. Provide both technical and non-technical reasons.
- Team E: Play the role of the CEOs of Chuttur and L&T and decide who will pay for the expenses. What are the ethical issues involved?
- Team F: Play the role of the CEO of L&T and discuss what are the global issues that the company need to consider in future projects? How to prepare the Indian engineers for the future?

- Team G: Play the role of the CEO of a competing US construction firm and discuss the threats and advantages offered by L&T in completing this global design project. How to prepare the U.S. engineers for the future?

Survey Instrument

Two questionnaires were used to evaluate student feedback on the case study. Each evaluation consisted of 23 bipolar descriptors (item). The students were asked to evaluate the effectiveness of the case study on a 5-point Likert scale (1 indicating an extremely negative rating and 5 an extremely positive rating). Since there were a total of 23 questionnaire items, items were mapped to the constructs based on information provided by LITEE at Auburn University. The questionnaire included items to measure the five constructs of *higher order cognitive skills improvement, self-efficacy improvement, ease of learning subject-matter, team working improvement, and communication skills improvement* (Table 1).

The students completed the questionnaires, included their comments and submitted them

along with their term projects. Statistical analysis was conducted using SPSS. After mapping the 23 items to the five constructs, Cronbach Alpha was computed for each construct. Cronbach Alpha ranges from 0 to 1 and a value close to 1 indicates that the items coalesced together well enough to represent the construct. Cronbach alphas were computed for each construct to examine if the selected items appropriately relate to the construct. There are several opinions on acceptable levels of Cronbach alphas. For example, Treacy (1985) recommends a value of 0.70 or higher, while Nunnally (1967) suggest a more strict value of 0.80. In this study since all the constructs were developed based on previous by LITEE, a cut off value of 0.7 was selected for Cronbach alpha.

RESULTS

The mean and standard deviations for each variable along with other statistics have been provided in the tables below. Table 2 shows the information for pre-test. Alternatively, Table 3 shows descriptive statistics for pos-test (i.e. after conducting the case study). To check for

	N	Mean		Std.	Variance	Skewness		Kurtosis	
		Statistic	Std. Error	Deviation		Statistic	Std. Error	Statistic	Std. Error
HOC_tot1	15	22.0667	.68638	2.65832	7.067	.023	.580	-2.029	1.121
EL_tot1	15	7.6000	.49570	1.91982	3.686	.034	.580	-1.078	1.121
SE_tot1	15	24.2667	.88084	3.41147	11.638	-.163	.580	-.548	1.121
TW_tot1	15	19.0000	1.02353	3.96412	15.714	-.468	.580	-.483	1.121
CS_tot1	15	11.0000	.56061	2.17124	4.714	.338	.580	-1.129	1.121
Valid N	15								

Table 2. Descriptive Statistics for Before the Case

	N	Mean		Std.	Variance	Skewness		Kurtosis	
		Statistic	Std. Error	Deviation		Statistic	Std. Error	Statistic	Std. Error
HOC_tot2	15	18.6000	.57570	2.22967	4.971	-1.023	.580	1.676	1.121
EL_tot2	15	8.4000	.51455	1.99284	3.971	-.892	.580	.560	1.121
SE_tot2	15	22.2667	.83647	3.23964	10.495	-.683	.580	2.554	1.121
TW_tot2	15	19.2667	.68638	2.65832	7.067	-.910	.580	4.819	1.121
CS_tot2	15	9.7333	.48272	1.86956	3.495	-.688	.580	-.254	1.121
Valid N	15								

Table 3. Descriptive Statistics for After the Case

Construct	Number of Items	Cronbach Alpha
Ease of learning subject matter (EL)	3	0.442
Higher order cognitive domain of learning (HOC)	5	0.873
Self-efficacy (SE)	6	0.795
Impact on team working (TW)	4	0.903
Communication skills (CS)	3	0.776

Table 4. Reliability before the Case

Construct	Number of Items	Cronbach Alpha
Ease of learning subject matter (EL)	3	0.302
Higher order cognitive domain of learning (HOC)	5	0.776
Self-efficacy (SE)	6	0.840
Impact on team working (TW)	4	0.854
Communication skills (CS)	3	0.846

Table 5. Reliability after the Case

the normality of the distribution, skewness and kurtosis have been calculated. At the level of significance of 0.01 ($\alpha = 0.01$), the critical value of skewness is ± 1.174 . For kurtosis, a value in the range of -1.21 and 2.86 satisfies the requirement of normality ($\alpha = 0.02$).

Reliability and validity of the instrument

Table 4 and 5 show Cronbach coefficient alpha for the seven constructs considered in the study. The Cronbach alpha is used to measure the internal consistency of the instrument, and assesses the reliability of the instrument (Cronbach, 1951). Reliability of an instrument shows the degree of consistency or repeatability of the measurement. Most of the constructs have a coefficient value of 0.7 or higher which is an acceptable value for survey research.

A review of the reliability measures for the constructs reveals some concern regarding ease of learning subject matter (EL). The construct has a relatively low reliability both before and after the case analysis. Since there are only three questions for EL, it is not practical to remove any question. Therefore, the construct was kept with the original items.

Assessment of Students' Learning

Analysis of Variance (ANOVA) has been used to compare means between before and after implementing case study. Table 6-10 shows the result of the ANOVA.

The findings suggest that there is significant improvement in higher-order cognitive domain of learning (HC).

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	90.133	1	90.133	14.975	.001
Within Groups	168.533	28	6.019		
Total	258.667	29			

Table 6. ANOVA-HOC

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4.800	1	4.800	1.254	.272
Within Groups	107.200	28	3.829		
Total	112.000	29			

Table 7. ANOVA-EL

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	30.000	1	30.000	2.711	.111
Within Groups	309.867	28	11.067		
Total	339.867	29			

Table 8. ANOVA-SE

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.533	1	.533	.047	.830
Within Groups	318.933	28	11.390		
Total	319.467	29			

Table 9. ANOVA-TW

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	12.033	1	12.033	2.932	.098
Within Groups	114.933	28	4.105		
Total	126.967	29			

Table 10. ANOVA-CS

Questions (open-ended)

The survey also captured the opinion of the students through a few open ended questions. Through analyzing the responses given by students several themes have been generated. The list below reflects students' opinions to improve the course (before case analysis):

1. More hands on, problem solving activities
2. Group work
3. Visit to a company
4. More invited speakers

The students' responses to the survey after the case study show that the case has achieved some of the above objectives. For example, one student commented, "I actually liked the case study; useful in solving multi-optional problems". Another student says, "The case is very beneficial because it let you tackle real world problems with real buildings and construction site". The students overall gave a positive response to the utilization of cases in the class. This is consistent with the results from ANOVA, where students' decision making and critical thinking skills has been improved.

DISCUSSION

This study was designed to determine the effect of case study on students' learning. Through defining five constructs of students' perception (i.e. learning outcomes), students' learning has been measured before and after implement-

ing the case. Using ANOVA, the mean for each construct for pre-test and post-test were compared. The results show that there is significant improvement in Higher-order cognitive domain of learning (HOC). While the averages for other constructs have been improved, these improvements have not been statistically significant. One possible explanation for this is the small sample size. It is recommended that the study be replicated using larger sample sizes.

Regarding the correlation analysis, it is shown that there is significant correlation among constructs in both pre-test and pos-test. Students' social skill has been significantly correlated with the team working skills. In that regard, it contributes to our knowledge and understanding of cases in enhancing students' learning.

Analysis of open-ended questions both before and after implementing the case showed that students were enthusiastic about having cases in the course. They specially referred to the ability of the case to provide more practical and hands-on experience about the subject. In addition they mentioned that through cases they can enhance their problem solving skills.

CONCLUSION

This study was designed to assess improvement in students' learning outcomes through using real world case studies. The findings suggest that case study significantly improves stu-

dents' higher-order cognitive domain of learning (HC). Educators can use cases to enhance students' higher order domain of critical thinking. Furthermore, working as a team on the case improved students' skills in working in team. It showed that case analysis is an effective learning experience for students that enables them to relate course material to the practice while improves their level of understanding about the subject matter.

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