INTEGRATING LITEE CASE STUDIES IN CONSTRUCTION ENGINEERING AND ENGINEERING TECHNOLOGY EDUCATION

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Abstract
Case studies are an increasingly popular form of active teaching and have an important role in active learning, developing the skills and knowledge of students in engineering and engineering technology. It is a well known fact that engineering and technology students are expected to be industry-ready and are increasingly being asked by potential employers to demonstrate "soft" skills (such as problem solving, team working, decision making, and business skills) in addition to their "hard" technical skills[1]. Therefore it is very important to prepare students for the increasing growth of complexity in their professional life, with the theory, management, and innovation as well as the knowledge creation. Laboratory for Innovative Technology and Engineering Education (LITEE) case studies are very valuable tools to introduce engineering students to the complexity of real-world problems and demonstrate how engineering companies work in global settings in this information age. The integration of LITEE case studies from Della Steam Plant into the GTEC 3412 Mechanics III class and Lorn case studies into the CTEC 4343 Safety and Health course are discussed in this paper and the results are presented.

Key words: Engineering education, active learning, LITEE Case studies, communication, interdisciplinary thinking, team approach.

1. Introduction

In every discipline great progress has been synonymous with innovation and technology. In our society, learning is not only knowledge, but it includes participation in social practices and adopting established norms [2-4]. It is also creating new knowledge collaboratively when dealing with complex situations such as engineering problems, which involve cross-disciplinary knowledge and innovative thinking. Success as an engineer requires, in addition to strong technical capabilities, skills in communication and persuasion, ability to lead and work effectively as a member of a team, and understanding of the non-technical forces that profoundly affect engineering decisions. Therefore, it is important that students should be prepared to meet the demands of industry, government and society that to be able to affect the solutions to global problems. Prados [7] recognizes that required skills are not likely to be acquired with traditional instructor centered lecture-based instruction and student based active learning can be achieved by integrating theory and practice into engineering classrooms.

LITEE case studies are group-focused, real-world problem-solving applications [4], [8-9]). They are projects that help introduce engineering students to the complexity of real-world problems and show how engineering companies work in the information age [9]. As reported by [10] , the cases also provide the students an opportunity to interact with each other in a productive environment, developing team work, problem-solving, and decision-making skills while learning from their peers. The use of LITEE case studies makes it easy for instructors to teach complex subject matter and give hands-on help to students mastering technological applications using group work and presentations.

2. Case study and Context

The major impetus for this effort was a part of an ongoing NSF Project (NSF DUE #0442531), LITEE initiated a grant competition in Fall 2008, to promote the use of LITEE's case studies in university classrooms across the country. Dr. Darwish was awarded this grant to use Della steam Plant and Lorn manufacturing case studies from LITEE. The Della steam plant case study was integrated into GTEC 3412 Applied Mechanics III class to provide students;

- Perspective and predictive maintenance techniques in power generation plants
- Importance of turbine generation units in power generation
- Vibration of turbine generation units and its affects
- Importance of decision making in real world.

Lorn Case study was integrated as one of the teaching tools into CTEC 4343 Safety and Health course:

- To teach knowledge of basic skills needed by engineers , including technical accuracy, an understanding of the codes and standards, and ethics when faced with real world problems,
- To provide skills to analyze safety awareness and communication,
- To give students a better idea of the role the expert witness plays in today's legal system, and the skills necessary to prove their point to a judge or board of directors,
- To emphasize the importance of safety in design and work places, including lock out/tag-out procedures, limit switches, and safety in theory and in practice.

GTEC 3412 is designed to be an introduction to the mechanics and analysis of flowing fluids such as water, oils, and air. Applications address fluid flow in pipes, open channel flow, fluid measurements, pumps, turbines and buoyancy. It is a senior-level course approximately the size of 45 students. CTEC 4343 Safety and Health course is designed for management of safety and health in the construction environment. It examines basic elements of a safety and health program for the construction general contractor, including OSHA regulatory requirements; junior or senior level course class size is approximately 55 students. Case studies were used as part of the teaching and learning tools in Fluid Mechanics and Construction Safety and Health courses.

3. Description of Della Steam Plant

Content of the case as fallows [3] Della Steam Plant is a steam power plant in the southeastern part of the United States. It has turbine-generator units in operation, which produce about 1,000 megawatts of power per day. One of the turbine generator units began to vibrate heavily after being restarted following a 2-month preventative maintenance overhaul. Lucy Stone, the manufacturer representative, recommended that the unit be disassembled, parts checked and replaced as needed, and then the unit be restarted. The cost of her recommendation was $900,000. Bob Make, the day shift maintenance engineer, concurred with Lucy's recommendation; however, Steve Potts, the engineer in charge of predictive management, disagreed. After considering data from sensors he had attached to the turbine generator unit, Steve concluded that the vibration was due to an oil whip. His recommendation was to restart the turbine generator immediately. There would be zero cost if he was correct, but the costs might be as high as $19.5 million if he had misdiagnosed the problem and the unit failed during restart. Sam Towers, plant manager, was in a dilemma. The top management had reduced the maintenance budget, and Lucy's recommendation was expensive. However, if he followed Steve's recommendation, the unit might break. Realizing that he needed to consider all technical, financial, and safety aspects, Sam called a meeting of Lucy, Bob, and Steve to arrive at the final decision.

Student tasks are to assume the role of
1. Lucy and defend her recommendation to stop the turbine generator unit and fix the problem;
2. Steve and defend his recommendation to restart the unit Immediately;
3. Sam and decide between the two recommendations and defend his choice;
4. A new technology group and discuss what might be done in the future to solve such problems.

4. Description of Lorn Manufacturing Case study

This case study is based on an accident that occurred at WMS clothing in 1991[2]. Jim Russell, a maintenance worker at Lorn Manufacturing Inc., lost three of the fingers on his left hand during a routine maintenance procedure on a cotton manufacturing device, the lap winder. This occurred when the lap winder he was maintaining suddenly came on. He filed a lawsuit against Lorn Manufacturing Inc., the designers of the lap winder device, for negligence. This negligence suit invoked the codes of standards that applied to the design and building of the lap winder. This case study allows students to follow jury deliberations as they hear testimony from two expert engineers and plant employees. The ultimate question to be answered in this case was whether Jim Russell, the plaintiff or the equipment designer/owner, Lorn Manufacturing, Inc. bears the responsibility for this particular injury and the safety of this particular type of machine. If the company is found liable, they will pay damages or if the employee were determined to be negligent, he would not receive any compensation at all.

The Lorn case study includes visuals of the textile machinery, detailed cutaways of the gear mechanism, full depositions of the plaintiff, defendant, expert witnesses and one of the lawyers comments on the case. The broader objectives of this case study are to expose a student team to poka-yoke approach to safety, corporate liability, ergonomics, engineering ethics, employee training, expert witnesses and industrial safety [2]

Student tasks are to assume the role of

1. Assume the role of defense. Provide evidence to the jury that the manufacturer's products meets the applicable Codes of Standards and/or Jim Russell is guilty of Contributory negligence.
2. Assume the role of the plaintiff. Provide evidence to the jury that the Lap Winder is manufactured poorly and does not meet standards and/or that that Lorn Manufacturing did not provide any safety training for their product.
3. Assume the role of the jury. Decide the outcome of the lawsuit based upon the arguments presented by the defense and plaintiff. Defend this outcome with the information provided by other two groups and the case study itself.

5. Development and Results

Zohar and Dori [12] reported that high academic achievers obtain higher scores on thinking, compared to low academic achievers. However, students of both subgroups can make considerable progress with respect to the initial finding if they are engaged in tasks which require a higher order of thinking skills, if alternative teaching methods are employed such as moving from passive instructor-based teaching to student-based active learning methods [5]. This study finding strongly suggests that teachers should encourage students of all academic levels to engage in tasks that involve higher order thinking skills. There is a need to develop meta-cognitive skills to promote active learning [10].

A total of 110 students were enrolled in the both classes. The majority of students were Caucasians, (approximately 95%) and males, (approximately 98%). Implementations of the case studies were modified to suit our engineering and technical content. In a traditional class setting we have implemented student activities based on the topics that demonstrate theoretical concepts in applied setting. At the beginning of the semester, participants were randomly assigned to teams and were given one of the two case studies in their mentioned classes above to analyze.

Teams were asked to prepare a detailed review, capturing the background of the situation and explain the process and outcomes. Each team worked independently of other teams and each team member is obliged to rely on the others to achieve the goal. All team members are accountable for both doing their share of the work and for understanding everything in the final product. Students were given abundant opportunity to seek clarification on any aspect of the case problem and also guided for researching technical information. 30% of the course grade was based on the case outcomes, so students were expected to make serious effort. Each team presented their final product in a formal report and oral presentations to class. Students were encouraged to contact real companies and use the web as well as the scientific journals and other supplementary books for gathering information. Students used power point presentations or pre-edited videotape; some students are more comfortable preparing their video tape so they can have a chance to practice and edit on the video**.** A role play simulation was implemented as explained in the case descriptions above, students were asked to enact different roles and justify their position and prove their point. They were evaluated on the content and the delivery of their presentation. Eight criteria were considered in content evaluations as follows:

1. Problem statement and identification of criteria;
2. Thoroughness, accuracy, and depth of analysis of technical factors;
3. Thoroughness, accuracy, and depth of analysis of nontechnical factors;
4. Identification and evaluation of alternatives;
5. Quality, quantity, feasibility, and relevance of recommendations;
6. Justification and support for recommendations;
7. Innovative/interest generated;
8. Connection to theory.

Furthermore, paper-based surveys were given at the beginning of the semester and also at the end as a post survey. At the beginning of the course, students seemed not to like the presentation part of the assignment, but their view changed at the end of the course and most of the students' comments were positive.
Such as;
"*At the beginning I did not like the idea of working teams but after completing the case study, my views totally changed. It was excellent opportunity for me to interact with fellow students, improve my engineering communications skills and apply theory into practice".*
"*After completing the Della Steam case study, I had an upfront understanding to the real world engineering problem solving".*
"*Lorn Manufacturing Case study thought me importance of communicating professionally between peers and the companies clients and also other people involved*".

5. Conclusions

The two case studies integrated in to GTEC 4312 and CTEC 4343 class delivery methods in this study are comprehensive problems that require a team approach, interdisciplinary thinking and technical knowhow. The use of technological tools and the implementation of active learning methods were well received by the students. Engineering and Engineering Technology curricula emphasizes the application of theory rather than pure science itself. The events of this decade (global economy, IT, international competition, diverse workforce, environmental sustainability, green manufacturing, etc), have shifted the focus of engineering and related technical education from a traditional approach to integrating theory into practice in the engineering classrooms [3]. Students' comments included that they learned better new theories using case studies which simulate the real environments of complex problems. Case studies provided them hands-on learning experience and improved their communication skills, and learning from fellow students provided motivation and self confidence.

In engineering, experience plays a crucial role, therefore using case studies as a teaching tool helps student to gain valuable engineering experience while in school. In short, group activities help students prepare to be team players, improve their individual study skills, teach information gathering and analysis, improve time management and presentations skills and more important, provide practical skills. The active learning approach positively influences and strengthens student/faculty relationship, as faculty members share their engineering experience with students. Implementing active learning into the traditional engineering classroom is challenging for the faculty, but it offers the opportunity to teach engineering principles in a hands-on format. It can be concluded that LITEE case studies are effective tools for construction of perceived skill development of students by providing them experience self-reported learning, intrinsic learning and motivation, and venue by learning from their fellow students. Post survey results being positive, indicating that the case studies were generally well received by and educationally advantageous to these students. Statistical analysis of data will be presented in future work.

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