2006-2328: AN EVALUATION OF AN ESTABLISHED CASE STUDY FOR ENGINEERING TECHNOLOGY EDUCATION

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Introduction

Engineering and technology educators focus on meeting existing and future needs of industry when designing the content domain and planning instructional methods in their discipline. However, undergraduate students in engineering and technology rarely have an opportunity to solve real world problems that require integration across several disciplinary branches of engineering and those outside of engineering. This makes it difficult for students to make the transition from academia to industry especially in an era where the principles of concurrent engineering are employed in new product design and development. Therefore, there is a strong need to bring challenging, industry involved problems into our classrooms today.

The case study approach has long been used in business education but only recently made its entry into engineering education but with significant momentum. Nationwide, case studies are becoming very popular educational tools throughout engineering and technology curricula. In fact, during the last ten years, over 1000 papers have been presented at the annual ASEE national conference describing the development and utilization of case studies. When they are designed and implemented correctly, case studies can be a very effective pedagogical technique. A good discussion that makes the case for their use has been provided by Barrott (2001), who promulgates four key advantages, including linking students to the real world, improving critical thinking skills, developing communication skills, and involving students in cooperative learning[1]. Although case studies can be implemented in the classroom in a variety of ways, and with varying levels of success, several authors have recently discussed appropriate methodologies and strategies for implementing their use [2,3,4]. There is, however, a need for a comprehensive review of the use of case studies in the engineering and technology classroom.

Need for Evaluation of Case Studies

Developing holistic case studies that possess an active industry component and also challenge students in the many facets of engineering and industrial management is a complex task that has been undertaken by relatively few experts. During the past five to ten years, such case studies have been developed at various institutions with the help of significant funding delivered by agencies such as the National Science Foundation. These exemplary case studies are now available for educators for adaptation and also possible direct use in the classroom. Several of these case studies have both engineering and management problems embedded within the case study. Successful classroom applications of these and other case studies developed by experts have received some attention in recent engineering literature. However, the dissemination of this information at the national level has been rather sparse and there is an urgent need to remedy this situation for the benefit of faculty and students alike.

As the concepts of collaborative engineering and product life cycle analysis become more prevalent in industry, the engineering technologist today has more opportunities to be engaged in new product design and development from the early concept stage[5]. Studies in engineering education have revealed that current curricula mostly emphasize science and mathematics competencies but fail to provide adequate opportunities to nurture and hone skills in teamwork, communication and systems approach to problem solving[5]. Therefore, there is a real need to bring more challenging, holistic, industry involved problems into our engineering technology classrooms today. [6,7,8]

Developing useful studies that possess an active industry component that also challenge students in the many facets of engineering technology is a complex task that has been undertaken by few experts. It is also quite imperative that case developers receive input from a wider audience on the implications of their learning tools so that successes and lessons learnt can be disseminated to all stakeholders in a timely fashion. The main objective of this paper is to provide an applied example of the use of a preexisting case study in a quality control course and demonstrate how instructors may measure the effectiveness of induced instructional changes using a combination of self-reported measures and authentic assessment. This paper presents one side of the ongoing study and the authors hope to continue to present the remaining part in another forthcoming publication.

Development of Case Studies at LITEE

The laboratory for Innovative Technology in Engineering Education (LITEE) established at Auburn University may be singled out as an exemplary source for case studies relevant to engineering and technology. The authors have established a partnership with this institution thereby providing the opportunity to examine various case studies that have been developed. The LITEE case studies focus on problem solving and are essentially aimed at improving student competence in areas that have been identified as shortcomings of current engineering and technology graduates as well as demonstrate abilities in many areas of engineering and management that have been central to the profession for decades. Raju and Sankar provide an operational definition of a ***case*** as " *…a description of a situation that frequently focuses on a problem or a decision facing people in pursuit of their occupation or interests. It usually involves the consideration of an actual example requiring the synthesis of a large amount of information and the development of recommendations* (Ref. 6, pp.36-37)." An examination of LITEE cases would reveal that they not only highlight the need for technical subject matter understanding and analytical skills, but also require teamwork, communication and systems thinking [9,10]. Most case studies have substantial integration of multi-media technologies thus providing for lively presentations that catch the attention of the viewers thereby promoting engaged learning[11,12].

Description of the Current Project

In Fall 2005, the Briggs and Stratton case study was employed in a limited fashion in an undergraduate quality control course titled TECH 391- Industrial quality control at Northern Illinois University. The authors of the case study (Drs P.K. Raju & C.S. Sankar from Auburn University) provided us with a condensed version of the case that specifically included some background information and then focused on a quality function deployment study that was originally completed by the Briggs & Stratton product development team. Minor editorial changes followed by further condensation of the material were completed by the authors of this article before disseminating the case booklet to students. It should be mentioned that TECH 391 was offered as an online course; hence all aspects of the case study including all that pertains to this article were completed via online instruction. The purpose of this course was to provide students with a background in industrial quality, focusing on techniques that yield better products and processes. The key topics covered are managing for quality, models for continuous improvement, describing processes, statistical process control and quality function deployment. The adapted B & S case study would serve as a platform to measure the effectiveness of this case study in delivering instruction on how to use quality deployment function in industrial practice. The quality function deployment process has made inroads as one of the foremost tool that is useful in translating customer needs into product specifications. The results of the process are typically presented as a characteristic figure that resembles a "house." Hence the QFD approach has also been called the House of Quality" method. Experts seem to agree that although this is a topic that can be taught at the undergraduate level, it is still an advanced topic that requires serious study and sound teaching. Any efforts made by the instructor to simplify presentation, diversify presentation to address multiple intelligences, or introduce more appeal by focusing on industry relevance should go in a long way in achieving objectives set for the learner, which is, to be able to analyze customer statements and proceed to objectively translate these into product specifications.

The Essence of the B & S Engine Redesign Case Study

In the Year 2000, Briggs & Stratton introduced two new engines, the Model M20, a sleeve-bore (iron) engine, and the M21, a cool-bore (aluminum) engine)[2]. These engines would replace M19. Design of the model M21 was involved taking one and a half years because testing revealed high oil consumption and unacceptable emissions. In addition, the information system used by the engineering department was not communicating effectively with the company's SAP R/3 systems used to manage the business operations. IS/IT was heavily used in R&D but not integrated into the enterprise-wide system. The case study allows students to follow the decision making process used by Briggs & Stratton managers to address these problems. The goal of this case study is to apply theories of product development, value chain and systems development life cycle to the product development of M21 and identify changes required. Further details can be accessed from the LITEE website and the referenced publication.

Project Implementation Details

The experiment introduced the subject matter of QFD using the traditional approach which was to present the material in a lecture format accompanied by slides prepared in Powerpoint™. Subsequently, an authentic assessment of student learning was completed by conducting a ten-item quiz addressing several aspects of QFD. See Appendix A for an actual listing of the items. The first five items were geared towards a general comprehension of QFD focusing more on the cognitive domain aspects of learning. The last five items were directly based on a QFD table analysis (not shown here) requiring a combination of analytical and quantitative skills. In essence, these latter five items were designed to address the topic at levels that determine appropriate level of comprehension to actively work on a QFD exercise as a member of a project team. Students were next asked to react to a series of five survey items that focused on their self perceived measures of learning and preferences. The actual items along with a statistical summary of obtained responses are portrayed in Table 1. It should be noted that items (6) – (10) referenced in this table imply items #s 6-10 on the previously mentioned ten-item authentic assessment tool shown in Appendix A.

Among other things, it is clear from the responses summarized in Table 1 that students overwhelmingly preferred examples with industry relevance and context in order to motivate them to learn more on the applications of QFD. Three out of four students indicated an industry case study as the obvious choice to further learning. Further, the results reveal that:

- a significant proportion of students indicated that their comfort level with QFD was low with almost nobody expressing a high degree of comfort
- a significant majority perceived that QFD would be valuable in industrial applications
- a majority made a sincere effort to learn
- a majority rated the subject matter posed above average challenges

At a minimum, we can conclude here that the students were able to recognize the relevance and importance of the subject matter but were clearly in need of improvised instruction to augment learning and motivate them. This represents a classical situation in engineering technology that calls for better learning aids as the needs are demonstrable and the potential to help willing students appears large.

Conclusion and Future Plan

Case studies have the potential to play an important role in addressing diverse preferences among learners. The discipline of engineering technology is inherently geared towards producing graduates that can seamlessly transfer from school to work and there is always a need to bring more real world experiences into the classroom. Case studies have a tremendous potential to address this issue and also promote attainment of desired outcomes of a four-year program such as teamwork skills, communication skills, problem-solving ability and life-long learning. This paper presented the application of a case study in teaching quality planning concepts. The experiment revealed that in QFD, we have an area of industrial quality that has great potential in terms of application and also the development of improvised learning material. The expressed desire of students for industry involved material was verified in this study. We hope that this article would inspire quality experts and instructional design experts to come together to work on collaborative projects as well as motivate instructors using other methods to teach QFD to share their insight. In a future article, the authors will elaborate on the remaining part of the study which includes the implementation of a parallel ten-item authentic assessment quiz and a five item self-reported survey both following the introduction of case study. The combined results of pre-test and post-test studies would shed some more light and provide for a more complete picture on this particular case study.

Table 1: Student responses following traditional instruction using Powerpoint™ slides

Item #	Item with options	Response % N = 14 students	Response % N = 27 students
1	How would you rate your understanding of the QFD process?		
	Very low……………………………………………………………….	0	7.4
	Low…………………………………………………………………	71.4	37
	High…………………………………………………………………	28.6	51.9
	Very high……………………………..	0	3.7
2	For items (6)-(10), which of the following best describes your approach:		
	I did not do any calculations and answered all items just by guessing..	0	0
	I did some calculations but it was mostly guessing………….............	14.3	25.9
	I did a whole lot of calculations but was not 100% sure what to mark for my response…………………………………………………………	35.7	18.5
	I studied and performed thorough calculations and 100% sure of my responses……………………………………………………………...	50	55.6
3	How would you rate your personal belief in the QFD process?		
	It adds absolutely no value to new product development…………….....	0	3.7
	It has but little value in new product development……………………...	7.1	18.5
	It has significant value in new product development………..................	85.8	70.4
	It is a must in new product development………………………………..	7.1	7.4
4	Rate the difficulty in learning the subject matter pertaining to QFD, compared to several other technical topics you are already familiar with:		
	QFD is a very difficult topic…………………………………………….	14.3	7.4
	QFD is not very difficult but poses above average challenges………..	64.3	77.8
	QFD is quite easy to learn and poses below average challenges…….....	14.3	11.1
	QFD is a very easy to learn topic……………………………………….	7.1	3.7
5	Forgetting the time constraint this semester, which of the following approaches will be most favorable to you to learn more about QFD?		
	The textbook has everything. I just need to read more carefully……….	0	3.7
	Would like to read more books on the subject so that I can do a detailed comparative study……………………………………………..	7.1	7.4
	Would prefer to study the textbook pages some more and have a group discussion with fellow classmates…………………………………..	14.3	22.2
	Would like to see where and how QD was used in an actual industry case study to solve a problem…………………………………………..	78.6	66.7

Appendix A
Authentic Assessment
(Conducted before introducing case study but after traditional instruction was completed)

The purpose of this appendix is to provide the reader with a substantial preview of the ten-item authentic assessment tool. Please contact the authors for further details on the referenced document files if required.

1. The quality management tool that is most useful and directly intended to translate customer desires into product specifications is known as the _____________:

a. Pareto chart
b. house of quality diagram
c. concept of stratification
d. scatter plot

2. What is the usual starting point in the QFD process?

a. decide in what areas your product should be better than those of your competitors
b. determine the correlation between the technical requirements of the product
c. conduct customer surveys and focus group studies to do a needs assessment
d. determine the operational goals for all technical requirements of the product

3. The development of the QFD process is attributed to:

a. Taguchi
b. Garvin
c. Akao
d. Deming

4. The money invested by a company in a QFD study addressing new product development or the redesign of an existing product is most appropriately accounted for under which cost category?

a. prevention
b. appraisal
c. failure
d. intangible

5. The ultimate goal of the QFD process is to:

a. engage the design department in the use of newly available quality control tools
b. ensure that defective products are caught before they leave the plant
c. create products and services that have the most demand
d. facilitate continuous improvement of all manufacturing processes in the plant

<u>Items (6) –(7) are based on the file saved as ***camera-qfd..doc***</u>

6. Retrieve the QFD process file named ***camera-qfd.doc***. This is a diagram depicting a QFD study for a new camera. The calculated importance rating that goes into "**Cell D**" would be equal to:

a. 33
b. 23
c. 27
d. 7

7. The calculated importance rating that goes into "**Cell E**" would be equal to:

a. 23
b. 32
c. 25
d. 17

Items (8) –(10) are based on the file saved as ***manufacturing-qfd.doc***

8. Retrieve the QFD process file named ***manufacturing-qfd.doc***. This is a diagram depicting a QFD study for designing a handlebar stem for a mountain bike. The calculated importance rating (absolute weight) that goes into "**Cell A**" would be equal to:

a. 213
b. 193
c. 157
d. 132

9. The calculated importance rating (absolute weight) that goes into "**Cell B**" would be equal to:

a. 162
b. 213
c. 132
d. 243

10. The calculated importance rating (absolute weight) that goes into "**Cell C**" would be equal to:

a. 183
b. 171
c. 147
d. 125

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