

# COLLABORATING ON A CASE-BASED COURSE IN QUALITY MANAGEMENT AND CONTROL

**Lyndia STACEY, Ada BARLATT and Steve LAMBERT**  
University of Waterloo, Waterloo, Canada

## **ABSTRACT**

Quality Management and Control is a fourth year technical elective course focusing on analysis, evaluation and improvement of processes and designs. It has been taught in a conventional manner using lectures, assignments and exams for several years. The instructor, who is also one of the authors, was asked to teach this course for the first time and wanted to stress the real world importance of quality control in engineering design and provide students with realistic applications of quality management techniques. For this reason, the instructor chose to present the theoretical part of the course during the first half of the term by traditional lectures but use a case study approach for the second half of the term. Multiple available cases were reviewed for general alignment with the course objectives, and three case studies were chosen. The instructor then worked with the case-writing group to create case assignments to supplement the original case study, and concentrate student discussion around specific course objectives. There were several challenges associated with creating this case-based course. These are presented as well as the development process, implementation strategy, suggestions for improvement, student feedback and instructor observations.

*Keywords: Case studies, engineering education, deductive approach, inductive approach.*

## 1 INTRODUCTION

Traditional engineering education uses a deductive approach: an instructor explains theoretical concepts through lectures and then follows with applications and an examination. This is a teacher-centred approach which has many benefits; however, this method typically omits the motivation for students to learn course material. A deductive approach can also make it difficult for students to realize the importance of the concepts being taught. Inductive teaching, on the other hand, is one way to instil motivation and expose the importance of theoretical concepts [1]. The case method is an example of this approach. A case study is a description outlining the complexity and context of a real-world challenge faced by a particular decision maker. It requires students to analyze the problem and make a decision in the role of the original decision maker [2]. An important aspect of a case is that there are multiple solutions; this allows students to increase their tolerance for ambiguity [3]. By exploring problems and various solutions, students are inspired to use creativity and innovation [4]. The case method also encourages students to participate in activities, as opposed to the traditional lecture method. Students are known to learn more effectively when they are actively involved with their learning and it challenges them to accept responsibility for their own education [3]. Although the case method has been proven effective, it is not prevalent compared to traditional lectures in engineering education [4]. With an increasing emphasis on outcome-based assessment criteria by the Canadian Engineering Accreditation Board (CEAB) [5], there is a need to implement pedagogical methods that work towards these goals. As preparation for the workplace, case studies were used in a Quality Management and Control (MSCI 551) course in an attempt to give students the opportunity to practice using quality control in engineering design. This course is a final (fourth) year technical elective as part of the Management Engineering undergraduate program at the University of Waterloo.

## 2 OVERVIEW OF CASE DEVELOPMENT IN MSCI 551

MSCI 551 focuses on the analysis, evaluation and improvement of manufacturing and assembly processes in order to increase quality. The overall objective is for students to be able to incorporate quality control during the design of a manufacturing or service system, which is a significant aspect of the Management Engineering curriculum and of management engineering design. The major topics of

MSCI 551 include process capability analysis, statistical process control, experimental design and acceptance sampling. During the Spring 2014 term, the course was redesigned by a new instructor. Students were introduced to quantitative methods and fundamental concepts in the first five weeks using traditional lectures and then, throughout the remainder of the term, learned new qualitative techniques and applied all methods and concepts to a series of case studies. The instructor chose case studies because she wanted a higher retention of information and an opportunity for her students to integrate multiple concepts. By developing an implementation strategy using case studies, students applied both quantitative and qualitative methods in the context of real world designs and processes.

## 2.1 Case Selection

The teaching objectives for the course were used to guide the case selection process. The cases were chosen from previously developed case studies by Waterloo Cases in Design Engineering (WCDE), a group on campus that creates case studies for use throughout the engineering curriculum in order to enhance learning. The selected case studies had to include sufficient context and complexity that would allow students in MSCI 551 to:

1. Accurately summarize aspects of a quality management system
2. Confidently assess a system for quality improvement opportunities
3. Design and evaluate a quality management system for a process
4. Successfully apply documentation and analytical techniques related to quality
5. Effectively communicate about quality management systems

The cases were also selected by considering the presumed students' areas of interest, since this can increase their engagement [4]. The problems related to the current world and to everyday business. The purpose of this was to show the relevance of course content at a level of complexity that appropriately challenged the students [6]. Multiple cases were reviewed and three cases were chosen (Table 1) based on the instructor's evaluation of the cases' connection to the course objectives.

*Table 1. Case studies selected for MSCI 551 and their respective problem statements*

Case No.	Case Title	Original Problem Statement	Targeted Course Concept(s)
1	2008 Canadian Listeria Outbreak [7]	The design of the food safety system and regulatory policies at Maple Leaf Foods needed to be studied for shortfalls and for improvements to prevent a similar incident.	Statistical Process Control Continuous Improvement: -DMAIC <sup>1</sup> [8] -Six Sigma
2	SteriPro Operations Analysis [9]	An opportunity exists for process improvements that best achieve optimal reprocessing volumes. This new process had to meet design constraints as well as relevant regulations and standards.	The impact on quality in product and process design: -PDCA <sup>2</sup> Cycle [8] -Quality of process design -Quality of product or service design
3	Sleeman Bearing & Gearbox Failure [10]	There is a need to investigate the design of a gearbox following bearing failure in order to determine detection methods to prevent future failure.	System Maintenance/Reliability -Lean Maintenance -Preventative, predictive and proactive maintenance

## 2.2 Case Assignment Development

The selected case studies were originally created for other courses or had slightly different learning objectives. Therefore, the focus of each case did not necessarily fit MSCI 551. To correct this, the instructor outlined a new problem statement for each case that was more specific to the course material. A WCDE staff member used this to create a supplemental case assignment. In some instances, certain information was missing that was necessary for students to solve the new problem statements. WCDE staff procured this information by directly contacting the industry partner with

<sup>1</sup> DMAIC stands for Design, Measure, Analyze, Improve and Control

<sup>2</sup> PDCA stands for Plan, Do, Check and Act

whom the case was originally developed. These assignments forced students to analyze designs and processes for failures or weaknesses. Afterwards, the assignments required a redesign of the original process to prevent a similar failure or create an improvement. This is a valuable aspect of engineering design since quality control and continuous improvement are constantly applied in industry and need to be emphasized to students during their undergraduate career.

### 3 IMPLEMENTATION STRATEGY

There are multiple ways of implementing the case method, each varying with the instructor, course, and case study. However, there are some basic implementation practices that are highly recommended, including giving time for individual student preparation, small group discussions, and large class discussions [2]. It is also good practice to give consistent evaluation and feedback when using multiple cases [2]. Table 2 summarizes the implementation steps, student reactions, and instructor comments. The students were first asked to individually read a case and the associated assignment, and then complete a comprehension quiz. Small group discussions followed by full-class discussions were employed to create an engaging atmosphere for examining multiple solutions. Students self-selected groups of 3 or 4 and gave short presentations to receive feedback from their peers and instructor as preparation for a formal report. The same groups were used for all three cases and they presented a solution for each case study during which they had to justify their decisions.

*Table 2. Summary of implementation steps used for each case study*

Step	Description	Samples of Student Reactions	Instructor's Comments
1	Individually read case study and reflect on problem statement	"It was much better than reading concepts out of the book."	They need to read on their own in order to contribute to group discussions.
2	Small comprehension quiz (students given 10 minutes to complete)	Not applicable	This was important to motivate students to individually read each case.
3	Small group discussions (not asked to reach a consensus on a solution)	"It was easier to see other perspectives of the cases which ultimately sparked new ideas."	This step was helpful to bounce ideas off each other and clarify information.
4	Large group discussion (mediated by instructor)	"The class discussions were the best. It was an open discussion and it let everyone bounce ideas off each other and not just one person talking."	Discussing cases created a more fun and engaging classroom environment than a traditional lecture.
5	Small group presentations on proposed solution	Not applicable	These were interesting to hear since each group created a different solution.
6	Feedback on solution by instructors and peers	Not applicable	This step was just to make sure the students were on track for their report.
7	Formal report on case solution	"The case studies in this course gave me a better understanding of course material because I needed to incorporate course concepts for the quizzes and reports."	It was great to confirm that the students learned the theoretical material since they were able to apply it to the cases in a formal report.

#### 3.1 Collaboration with Industry

Two industry representatives from Sleeman Breweries, Guelph, provided extensive support on developing a case assignment for the Sleeman Gearbox case study [10]. They provided more detailed information regarding their facility to help students solve the refined problem. Their company hires many engineering co-op students from the University of Waterloo, so they had an obvious incentive to participate. The representatives' enthusiasm towards the case method was evident as they reviewed each student presentation and offered insight to the solutions based on their industry perspective.

#### 4 STUDENT FEEDBACK

A student survey was conducted near the end of the semester for continuous improvement. The baseline for comparison was the lecture component of the course used in the first half. The same students were exposed to two teaching methods and were asked to self-reflect on their ability to appreciate and understand course concepts using case studies compared to the lectures. Questions included self-evaluations of student understanding and ability to apply the concepts, opinions on each case study, and suggestions for improvement (Figures 1 and 2). The overall response from the students was very positive. There were numerous comments that they enjoyed real life applications and the instructor's use of the case method. Students appreciated that the case study activities connected to real life, and therefore demonstrated the importance of the course concepts.

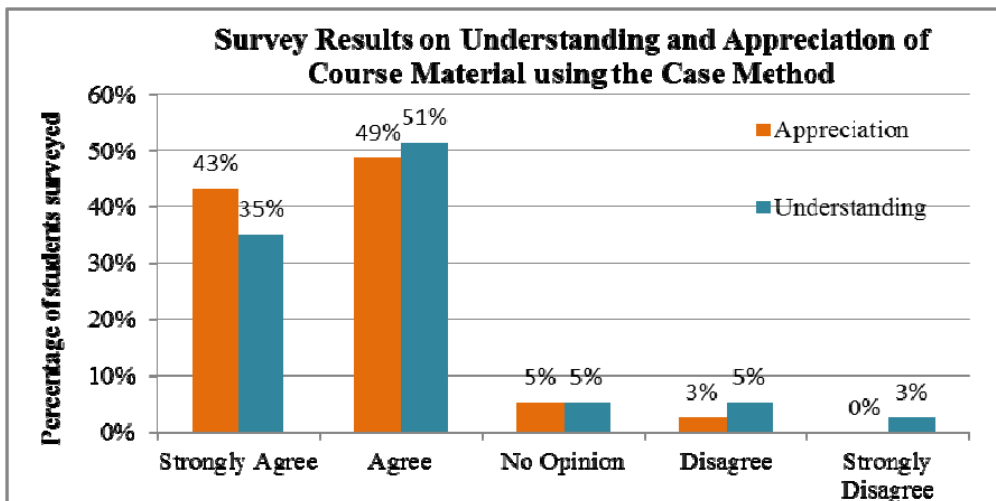


Figure 1. Student feedback results based on survey questions “Did the case studies give you a better understanding/appreciation of the course material?”

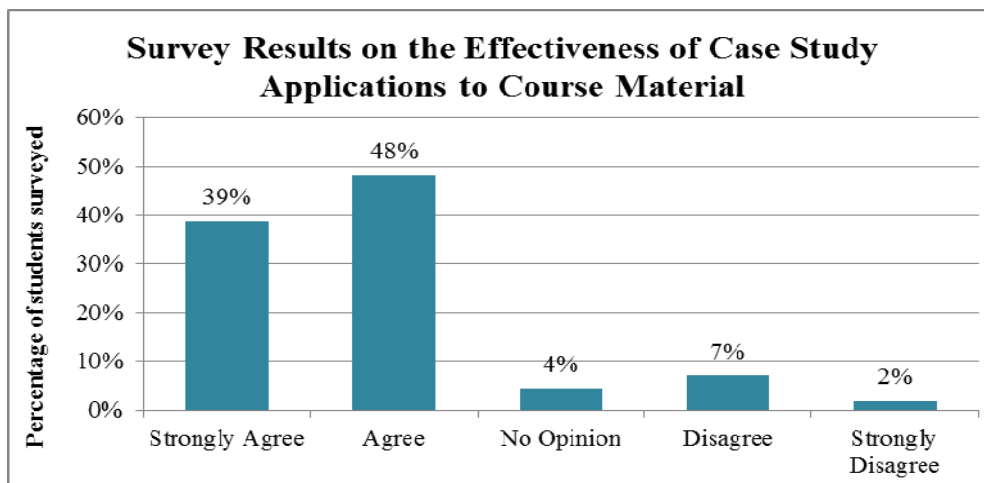


Figure 2. Student feedback results based on survey question “Were the case studies an effective application of course material?”

Figure 1 indicates that the majority of students agreed that the three case studies gave both a better understanding and appreciation of course material. There were numerous student comments that the cases showed real world connections which demonstrated the relevance and importance of course material to the workplace. Student comments suggested that the basic understanding of concepts came directly from the traditional lectures, but the cases forced them to think more deeply about course concepts through application and design. The students who disagreed in Figure 1 felt that the case

studies were either too open-ended, there were too many assumptions, case topics were not interesting, or the cases did not improve their understanding of the course material.

From Figure 2, the majority of students again agreed or strongly agreed that the case studies were an effective application of course material. Students provided feedback that the applications were interesting, connected to relevant real-world problems, and they were able to use course concepts to generate a solution. Most comments by the minority of students who disagreed with this question said that they were not interested in the specific application or that they felt that certain cases did not allow them to apply techniques from class.

Formal course evaluations are conducted for all undergraduate courses. The instructor was rated highly overall for this course. Specific categories that were rated high, and pertained to the teaching approach, included an appropriate level of complexity, organization, professor-class relationship, and the contribution of assignments to create a better understanding of concepts.

## 5 DISCUSSION

Case-based instruction has been used numerous ways in engineering curricula, with positive results in the literature [11]. The instructor for this course observed that the learning environment was more engaging and interactive when the case method was used, compared to traditional lectures. This aligns with other studies and is attributed to an active-learning component as well as collaborative learning [1]. Although the MSCI 551 class was more engaged using cases, the traditional lecturing was pertinent to the students' understanding of fundamental concepts and should remain in the course design. A recent study showed that students preferred traditional lectures for developing a better understanding of concepts but, compared with cases, they were much less engaged and less active [11]. This study, as well the course structure in MSCI 551, suggests that students learn best when these methods are combined. Traditional lectures are effective at providing comprehension of concepts and the case method is effective at engaging students in applications of these concepts.

A national survey in the United States asked science faculty members their perceptions on the benefits of cases. The vast majority of faculty members agreed that cases improve students' critical thinking, encourage the development of deeper understanding of concepts, enhance engagement, provide students the opportunity to actively be involved in their learning, and integrate multiple concepts [12]. This was also evident in MSCI 551 in the quality of the formal reports. The reports demonstrated the students' capacity to incorporate quality control concepts to the context of a case study. The quality and level of effort, as well as their enthusiasm during group presentations and class discussion, reflected their engagement. During the MSCI 551 implementation, students successfully used multiple concepts to justify their decisions in the solution of a case problem. This success is partially attributed to the development of a case assignment. This was an important strategy for implementation in MSCI 551. It narrowed the scope to directly relate the case to the course teaching objectives to ensure that students focused on applications of course concepts.

The students were observed to be more thorough with their solutions when they knew industry representatives would listen to their presentation regarding a problem that was derived from the industry's facility. Students found industry feedback very insightful. Many of their solutions lacked a practical perspective; they relied heavily on their academic background and theoretical concepts. This was despite the fact that they had already completed five co-op work terms as part of their academic program. Industry feedback pushed students to think more about the context of the case and how the implementation of their solutions could present challenges in the workplace.

Not every student liked all case topics and some did not find the cases to be an effective application of course material. There was a common trend that negative feedback in the survey correlated with comments that suggested a lack of interest in the case study topic. Although engagement does not increase problem-solving abilities, it is suggested that engagement and interest in the topic makes students more willing to put in the effort to apply multiple concepts and provide a quality solution, which ultimately creates a deeper appreciation and understanding of course material. However, the percentage of students in this category was small; it is difficult to find a topic that is interesting to every student within a course. This also emphasizes the need to have multiple cases, covering an assortment of topics, in order to interest various students as well as demonstrate different applications. The main suggestion for improvement based on student feedback was to make the case studies less open-ended and provide sufficient information such that assumptions would not be necessary. This conflicted with student feedback on the course evaluations that the class was highly organized with

assignments that contributed to their understanding of concepts. Although an appropriate level of guidance should be expected from the instructor, this inherently goes against the case method as well as design. Therefore the request for less open-ended problems could instead mean that the students are intimidated by case studies even though they are indicative of the workplace.

### 5.1 Applying this Approach Going Forward

It is clear that lecture and case-based methods are complementary and beneficial to student learning. It is recommended to introduce theory by traditional lecturing and then use the case-based method for integration of concepts and applications. This teaching strategy uses cases to reinforce course concepts that have been covered at the beginning of the course with lectures. Instructors can also create case assignments that require integration of multiple concepts. This allows concepts in the course to build on each other and to be applied simultaneously to a realistic problem. The case-method ensures that these problems have real world context and complexity to further highlight the need to integrate concepts and use problem-solving skills in the workplace. The choice of case is important. To widen the case options, it is possible to select a case study with a problem and context that generally fits the course, and then focus the scope on specific learning objectives using a case assignment. If possible, it is also recommended to invite industry representatives to listen to students present their solutions, and provide feedback. It is not necessary that these representatives are from the same company; if they are within the same field, this industry connection will incentivize students to problem-solve and correctly apply course concepts so that they can be confident in front of practicing professionals. This strategy worked well in MSCI 551 and showed that there are other incentives for students besides grades.

### REFERENCES

- [1] Prince M.J. and Felder R.M. Inductive Teaching and Learning Methods: Definitions, Comparisons, and Research Bases. *J. Engr. Education*, 2006, 95(2), 122-138.
- [2] Maufette-Leenders L.A., Erskine J.A., and Leenders M.R. *Learning with Cases 4<sup>th</sup> Ed*, 2007 (Ivey Publishing, Richard Ivey School of Business).
- [3] Sankar, C.S., Varma, V., and Rajue, P.K. Use of Case Studies in Engineering Education: Assessment of Changes in Cognitive Skills. *J. Prof. Issues Eng. Educ. Pract.*, 2008, 134(3), 287-296.
- [4] Bozic, C.L. and Hartman, N.W. Case-based Instruction for Innovation Education in Engineering and Technology. *American Society for Engineering Education (ASEE) Conference*, 2014, Indianapolis, United States.
- [5] *Accreditation Criteria and Procedures 2014*, Canadian Engineering Accreditation Board, Engineers Canada, 2014.
- [6] Brady, P.A. and Lawson, J.W. Using Case Studies to Characterize the Broader Meaning of Engineering Design for Today's Student. *ASCE Architectural Engineering Conference*, 2011, California, United States.
- [7] Pearce C. *2008 Canadian Listeriosis Outbreak*. Waterloo Cases in Design Engineering, University of Waterloo, WCDE-00060-01, January 2013.
- [8] Aikens C.H. *Quality Inspired Management*, 2011 (Prentice-Hall, ISBN-13: 978-0-13-11975-5).
- [9] Smellie C., Quilan M., Dueck A., and Effa D. *SteriPro Operations Analysis*. Waterloo Cases in Design Engineering, University of Waterloo, WCDE-00060-01, March 2012.
- [10] Goncalves A., and Effa D. *Sleeman Bearing & Gearbox Failure Analysis*. Waterloo Cases in Design Engineering, University of Waterloo, WCDE-00060-01, January 2013.
- [11] Yadav A., Shaver G., and Meckl P. Comparing the Lecture Method with the Case-Teaching Method in a Mechanical Engineering Course. *American Society for Engineering Education (ASEE) Conference*, 2009, Texas, United States.
- [12] Yadav, A., Lundeberg, M., DeSchryver, M., Dirkin, K., Schiller, N.A., Maier, K., and Herreid, C.F. Teaching science with case studies: A national survey of faculty perceptions of the benefits and challenges of using case studies. *Journal of College Science Teaching*, 2007, 37(1), 34-38.