Investigation of the Benefits of Using a Case Study Method to Teach Mechanical Engineering Fundamentals Courses to Deaf and Hard of Hearing Students

Dr. Wayne W. Walter, Rochester Institute of Technology (COE)

Wayne Walter is a professor of Mechanical Engineering at the Rochester Institute of Technology (RIT). He received his B.S. in Marine Engineering from SUNY Maritime College, his M.S. in Mechanical Engineering from Clarkson University, and his Ph.D. in Mechanics from Rensselaer Polytechnic Institute. Dr. Walter has worked for the U.S. Army, Rochester Products and Delco Products Divisions of General Motors, and Xerox, and is a registered professional engineer in New York. He has thirty-five years experience teaching design related courses, and has developed expertise in the areas of robotics, and micro-robotics. He is currently working on the locomotion of micro-robots with micro-sensors and actuators, and on artificial muscles and sensors using electroactive polymers.

Dr. Michael G. Schrlau, Rochester Institute of Technology (COE)

Dr. Michael Schrlau is an assistant professor in the Department of Mechanical Engineering and the founding director of the Nano-Bio Interface Laboratory (NBIL) at the Rochester Institute of Technology. Dr. Schrlau is interested in several aspects critical to the interface of nanotechnology and biology, including nanomanufacturing, nanomanipulation, technology-biology interactions, and biomedical applications, and investigates micro/nanoscalefluid behavior and develops related micro/nanotechnologies for biological metrology. Dr. Schrlau earned his B.S. in Mechanical Engineering and Materials Science from the University of Pittsburgh in 1998. From 1998 to 2004, Dr. Schrlau worked for Kimberly-Clark Corp in roles ranging from R&D engineering to operations management. In 2009, Dr. Schrlau earned his Ph.D. in Mechanical Engineering and Applied Mechanics at the University of Pennsylvania for his research on carbon-based biological nanoprobes. After completing a postdoctoral fellowship in the Department of Pharmacology at Temple University, he joined the Department of MaterialsScience and Engineering at Drexel University as a research assistant professor in November 2009, where he led the research activities of the W. M. Keck Institute. During the same time, Dr. Schrlau was also an adjunct lecturer at the University of Pennsylvania in the Department of Materials Science and Engineering. His research appears in several high impact journals, including Nature Nanotechnoloy, ACS Nano, Small, and Nanotechnology, was featured in Nanotechnology (cover image) and ACS Nano, and has resulted in several patents. Dr. Schrlau actively supports graduate and undergraduate research and is active in nanotechnology K-12 outreach.

Dr. Patricia Iglesias, National Technical Institute for the Deaf

Dr. Patricia Iglesias Victoria is an assistant professor of Engineering Studies at the National Technical Institute for the Deaf, Rochester Institute of Technology, NY. Previously she served as an associate professor at the Polytechnic University of Cartagena, Spain. Her research focuses on wear and friction of materials, ionic liquids as lubricants and nanostructured materials. She maintains an active collaboration with the research groups of Materials Science and Metallurgical Engineering at the Polytechnic University of Cartagena and Materials Processing and Tribology at Purdue University, Indiana. As a result of these collaborations, some of her articles have been published in important journals of her field of expertise and her article entitled "1-N-alkyl-3 methykimidazolium ionic liquids as neat lubricant additives in steel-aluminum contacts" has been named one of the TOP TEN CITED articles published in the area in the last five years (2010). Since she started working at the National Technical Institute for the Deaf, Patricia has been actively involved in the field of deaf access technology and education.

Ms. Kate N. Leipold, Rochester Institute of Technology (COE)
Mr. Timothy Aaron Nichols, Rochester Institute of Technology

Timothy Nichols is an undergraduate mechanical engineering student at the Rochester Institute of Technology. He works with Dr. Walter, Dr. Schrlau, Dr. Iglesias, and Professor Leipold on the Case Study Project sponsored by the NTID Research Center for Teaching and Learning RCfTL. Mr. Nichols is in his second year as a student in the Honors Program at RIT, is a National Merit Scholar, and is an active member of campus life. He has served on the executive board of one of the largest student clubs at RIT. He is currently pursuing his bachelor's degree in Mechanical Engineering with a focus in aerospace, and plans to pursue a master's degree in Mechanical Engineering once his undergraduate work is completed.

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Abstract:

Case studies are routinely utilized in college business programs to engage students in real world applications and help them better appreciate the importance and relevance of fundamental principles. However, in engineering courses, case studies have not been fully utilized. The hypothesis of this project is that case studies will engage the interest of students, improve their performance in these courses, and ultimately improve their retention. Here, we report the development of a case study activity for Mechanics of Materials, a core engineering course in the Mechanical Engineering undergraduate curriculum, to help engage and interest students, especially deaf and hard of hearing (HoH) students. Using a universal design approach, the activity focused on the Hyatt Regency Walkway Collapse in 1981 and requires students to perform related design calculations and discuss the impact of the events that led up to the accident. Initial assessment of a recent implementation showed the activity stimulated discussions, reinforced engineering fundamentals, helped connect students to the context of engineering concepts, helped relate course content to real world applications, and helped students better understand the implications of engineering decisions.

Introduction

The case study method of teaching is used routinely in college business programs but is not widely used in teaching engineering courses. Some examples exist in the literature that show that it engages hearing students' interest and helps them better appreciate the importance of understanding fundamental principles, that otherwise may be somewhat dry. Xu and Zan (2008) found that "Case study method of teaching, originated from the Harvard Business School in 1919, has remained its validity around the world. It is an indispensably part of the successful teaching by making use of real world scenarios, instead of relying on academic theory as methodology. Thus, case study method of teaching will help strengthen one's ability of analyzing problems, evaluating alternatives and making action plans. Case study method of teaching insists more on participants centered learning." The authors Xu and Zan felt that the role of teachers and students change. Teachers serve as guides to learning, and students are in control of a learning process that is self-paced. [1]

> *"Compared with traditional teaching, the case study method of teaching is an interactive learning approach, which changes the role of students from passive to active participants."* [1]

Herreid [3] makes the point that simply lecturing students about a topic is not very effective in helping them remember anything about it. The medical profession has been aware of this for many years, and has always used "war stories" to instruct their interns and residents. The formal use of stories, called case studies, was introduced into Harvard University's law and business school about 1900, but was not formalized until thirty years ago at McMaster University when they introduced the storytelling method, called Problem Based learning (PBL), into their medical school curriculum. Two groups, the University of Delaware and the University

of Buffalo, have made extensive in-roads in using case-based teaching in science and engineering and have received extensive financial grant support from the National Science Foundation and others. The University of Delaware has urged the adoption of the PBL approach in every undergraduate discipline on its campus.

Case studies have been implemented in engineering courses with success. Anwar (2001) stated: "Like its law and business school counterparts, the engineering case presents a scenario that practicing engineers are likely to encounter in the workplace. Providing students with case experiences can be viewed as equipping future engineers/engineering technologists with the tools they will need to effectively perform in industry". The authors used the method successfully to teach an engineering technology course in the fundamentals of semi-conductors [4]. Similarly, Yu and Zhang [2] found that actual failure cases are more effective in teaching computer network engineering than made-up theoretical case studies which have no flaws.

Clearly, case studies can significantly improve learning and retention in a variety of disciplines. The method has been used effectively with hearing engineering students, and in fact, a National Science Foundation (NSF) website on engineering case studies is available [5]. However, there appears to be no reports in literature of studies where the method has been used successfully to stimulate deaf and HoH engineering students.

At RIT, there are over 96 deaf and HoH students in Engineering majors: 26 in the college of Engineering (11 Mechanical, 4 Chemical, 6 Biomedical, 1 Computer, 2 Electrical and 2 Engineering Exploration), 44 in the College of Applied Science and Technology (15 Mechanical, 14 Civil, 3 Manufacturing, 4 Electrical, 3 Computer, 2 Electrical/Mechanical, and 3 undeclared) and 24 in transfer programs. To investigate the impact case studies on deaf and hard of hearing student learning, we developed a case study activity for Mechanics of Materials, a core engineering course in the Mechanical Engineering undergraduate curriculum where students learn critical fundamental concepts and principles. The hypothesis of this project is that the case study method will engage the interest of deaf and HoH students, improve their performance in these courses, and ultimately improve their retention.

Methods

We developed a case study activity, focusing on the Hyatt Regency Walkway accident in 1981, for 0304-347 Mechanics of Materials at RIT. In brief, the Hyatt Regency Walkway Collapse resulted from the failure of the chief design engineers to do due diligence on the approval of a design change proposed by the contractor to install the walkways differently than as designed. The walkways collapsed at a tea dance being held in the hotel atrium, and 114 people were killed, extensive litigation resulted, and the chief engineers lost their professional licenses. The accident provides students the opportunity to apply Mechanics of Materials concepts to analyze the design failure as well as investigate the ethics of the situation and appreciate the impacts resulting from engineering decisions.

A two-part case study packet, designed and developed by undergraduate hearing and deaf student researchers who have previously taken the course, was used to implement the case study in each section. In the first part, a reading assignment with video links and a post-exercise questionnaire on the reading were posted on myCourses, an RIT online course management tool

available to all students enrolled in the course. The post-exercise questionnaire included the following questions to be answered in essay form:

1. What happened during the technology failure, disaster, or accident?
2. What was the root cause?
3. How could it have been avoided?
4. What were the consequences (any loss of life, injuries, loss of property, legislation resulting from the event, loss of engineering licenses, etc.)?

An on-line discussion forum was planned on myCourses as a follow-up activity.

In the second part, Mechanics students worked in teams to do some stress calculations focused on the actual failure of the walkway box beam to withstand the load. Students were asked to calculate the loads in the rods supporting the box beam as designed, and as installed by the contractor, and to compare the results. The total assignment accounted for 2-3% of their final overall grade.

In the Winter Quarter (December 2012 to February 2013), the Hyatt Regency case was introduced to two of the three sections of Mechanics. Section 1 did not review the case, and acted as a "control." Sections 2 and 3 read the case material posted on-line, and took the reading quiz. This was followed by an on-line discussion for an hour. The discussion was "seeded" with a question to get the student discussion going focused on the failure of the design engineers involved to do due diligence on the design change implemented by the contractor. Both sections then proceeded with the second part or the calculations/analysis part of the case study.

The impact of the case study on student learning was accessed using formative and summative assessment. Formative assessment was conducted using College-wide course evaluations and, as shown in Figure 1, a customized course-specific questionnaire at the end of the course. In the course specific questionnaire, all students were asked to rank the importance of certain course aspects to their learning, including lecture, homework, and the newly introduced cased studies. Summative assessment was conducted from student performance on case studies, homework, quizzes, exams and the overall course. However, only the formative assessment from the course-specific questionnaire was available by the publication time of this article and reported here.

Results and Discussion

Students in the two sections that reviewed the case were asked to complete anonymously the evaluation form shown below in Figure1, which asked how effective the case study was in learning the material compared with the other components of the course like lectures, quizzes, homework (See Question 2). There were also three questions specifically addressing the case study, broken out in a separate group (See Question 3). Results and comments are shown in Figures 2 and 3. Students generally rated the case study highly on each of the three questions in Question 3 (Figure 3), but not as well compared to other course components listed in Question 2 (Figure 2). Some student comments were critical of the implementation. Some said too much time elapsed between when the case was first introduced and the reading was assigned, and when the calculations were due. Others pointed out that the case study was worth only two or three quiz grades depending on the section, and felt it was too much work for the limited credit they received for it. Since the lowest quiz grade was dropped, some students chose not to do it at all. Overall, however, the results are encouraging, although limited. More data assessment is clearly

needed. We only had one deaf/HoH student in the first implementation, but there will be a larger number of deaf/HoH students in these classes next year. More data is needed on how case studies affect deaf/HoH students.

Conclusions

Initial assessment of a recent implementation showed that the case study stimulated discussions, reinforced engineering fundamentals, helped connect students to the context of engineering concepts, helped relate course content to real world applications, and helped students better understand the implications of engineering decisions. However, the team knows that further investigation needs to be done. Future actions will include:

1. Better implementation over a shorter time period. The current implementation had a time gap of three weeks between the on-line discussion and the team-based calculations, as a result of the exam schedule. This did not work well.
2. Redefine the Hyatt Regency case study and offer it again next year, after a complete summative data analysis.
3. The team can benefit from some instruction and guidance from faculty proficient with case studies implementation, either at the University of Buffalo or the University of Delaware.
4. Add more weight in the course grading rubric, both for the discussion portion and for the team-based analysis.
5. Complete an extensive summative assessment, and use it to help guide and devise alternative implementation approaches and better ways to utilize it in the classroom. As an alternative to on-line discussion, an in-class face-to-face discussion will be tried and evaluated.

The case study method of teaching is new to engineering students, and may not rate as highly compared to conventional lectures, recitations, homework, and quizzes, but adds value by virtue of the three items in question 3 of the course evaluation that it did well on (introducing students to real world applications, helping students understand the implications of engineering decisions, and reinforcing course concepts)

The team has found that it is difficult to find cases with clearly defined technical causes that can be easily tied to the Statics and Mechanics courses through calculations that students in those courses can perform.

The project is currently on-going, and has been implemented once only. More learning is anticipated as the team gets farther along, but some observations above are already clear. More interesting learnings are sure to follow.

Bibliography

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(1) How well were the following topics covered?

(5–very well, 3–somewhat, 1–poorly)

Force, Stress, and Shear	5	4	3	2	1
Hooke's Law	5	4	3	2	1
Stress Concentrations	5	4	3	2	1
Torsion and Deformation	5	4	3	2	1
Bending	5	4	3	2	1
Composite Bodies	5	4	3	2	1
Moment Diagrams	5	4	3	2	1
Shear Stress in Beams	5	4	3	2	1
Mohr's Circle	5	4	3	2	1
Combined Loads	5	4	3	2	1
Transverse Loads & Deflection	5	4	3	2	1

(2) How effective/important were the following in learning the material?

(5–very effective, 3–somewhat, 1–not effective, 0–not used)

Lectures	5	4	3	2	1	0
Quizzes	5	4	3	2	1	0
Homework	5	4	3	2	1	0
Recitations	5	4	3	2	1	0
Office Hours	5	4	3	2	1	0
Mechanics Text	5	4	3	2	1	0
Practice Problems	5	4	3	2	1	0
Case Study	5	4	3	2	1	0
Other (please state)	5	4	3	2	1	0

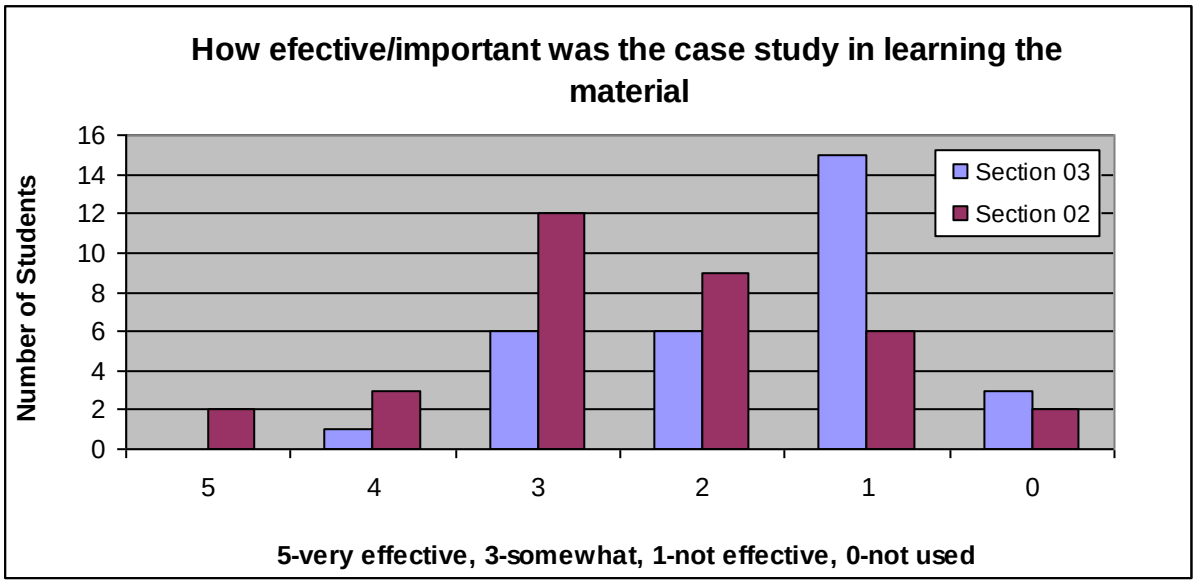
(3) How effective was the case study in:

Relating course content to real world applications	5	4	3	2	1	0
Reinforcing course concepts	5	4	3	2	1	0
Understanding implications of engineering decisions	5	4	3	2	1	0

(4) What helped you the most in the course?

(5) How would you improve the course?

Figure 1. Course Evaluation Form for Mechanics Winter Quarter 2012



Student' comments

Section 2:

- "Make the case study worth more, or make it easier, because it seemed to be too much work for only one quiz grade"
-"Case study, it got me much more interested in course content"
-"Change the case study"

Section 3:

-"Eliminate the case study. The case study assignment required an excessive amount of time that has not worth what provided"
-"Case study: Should be more planned out and gave more given information to solve the actual scenario rather than the "worst case"".
-"make case study easy to understand"
-"I liked the idea of case study but it had poor execution. Number given and numbers online varied and make the work confusing. Also, it should be worth 2 quiz grades so it won't just be dropped if it is the lowest quiz grade. Many people simply chose not to do it because of that. "
-"The case study had potential, but the timing and the way it was presented made it nearly useless"

Figure 2. Results of question 2 of course evaluations and students' comments

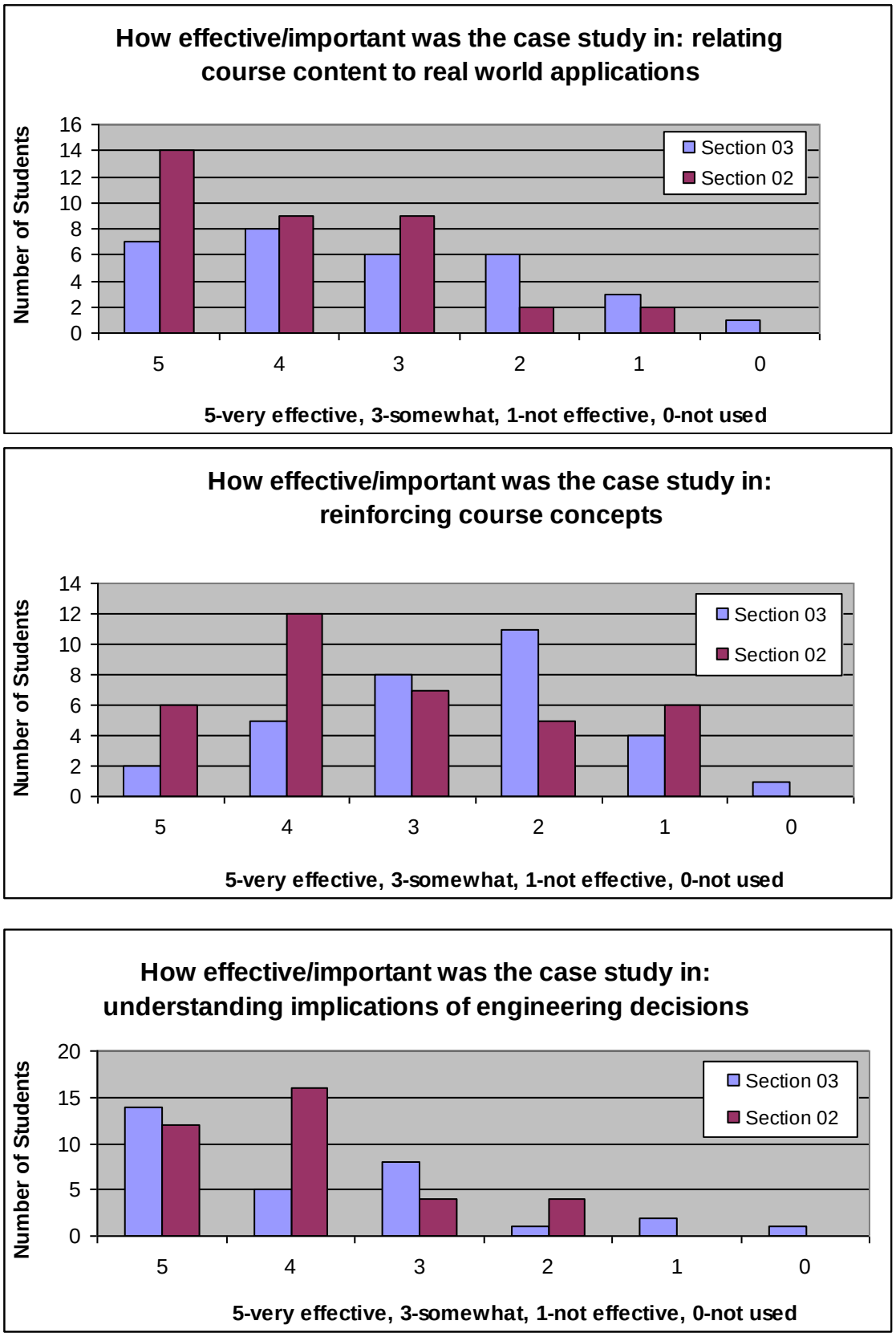


Figure 3. Results of question 3 of course evaluations