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Accentuating the Positive: Including Successes in a Case Study Survey Class

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Case studies have been used in engineering programs and classes as examples of, "what not to do." The authors created a one hour elective course, geared at upper level undergraduate students in a general engineering program. This course focused on engineering case studies, but with a twist: instead of focusing solely on engineering failures, successes were also included. The course was implemented in a seminar format. Early in the semester, guest lecturers including faculty and program alumni working in industry presented a case study of their choosing. As the students gained familiarity with the presentation style, student pairs presented case studies of their choice. Each week, two to three presentations were followed by general discussion. Students completed a short synopsis form that included a summary of the main points and the key takeaway for each case. At the end of the semester, the students wrote personal reflection papers on what they learned in the course during the semester. Leaving the choice of the cases discussed to the presenters (both guest lecturers and students) resulted in inclusion of cases beyond the classic examples (e.g. the Challenger, the Ford Pinto, the Hindenburg, the Titanic). Some of the less widely discussed failures presented included the groundwater contamination at Camp Lejeune, North Carolina, the structural failure of the Skyline Tower in Washington, D.C., the crash of Swissair Flight 111, and the excessive deflection of the London Millennium Bridge. Also interesting was the various engineering successes such as the Brooklyn Bridge, the Hoover Dam, the Grand Canyon skywalk, and rural electrification. By expanding the course topics to include successes, what, if anything, did the students gain? Comments from the students' papers are insightful, and indicate that inclusion of successes enhanced the students' learning. One observation of note from this first offering was the emergence of some common threads among both the failures and successes, including most notably the role of effective communication. The course is being offered again in the spring of 2016, and the authors are exploring additional methods of assessing the students' learning as well as emphasizing the common threads.

Introduction

Case studies have been utilized in engineering to teach ethics and demonstrate the practical application of learned skills[2,4,6] since the 1960s and 1970s[7]. Data has been collected regarding their use in lieu of, or supplementing, lecture-based delivery of information[1], and utilizing case studies enables students to actively participate in class and allows them to see engineering as it applies in the real world[8]. While some of the faculty interviewd by Haws use both real and hypothetical case studies, there is no mention of *engineering achievements* utilized in the study of

mechanical and electrical engineering programs at seven universities[3]. However, it seems that not only has use of case studies in engineering not become the norm[6], but the majority of these case study-based classes focus on failures. This is despite a recommendation by Pritchard suggesting that utilizing "good works" (where people have risked their jobs or lives to fix a wrong) in case studies would be beneficial[5].

Curiously, upon performing a literature search to see where engineering successes might be utilized, the "historical" aspect arose[9–11]. In these papers, the authors describe using historical structures (including well-known bridges and structures such as the Eiffel Tower) for classes such as Statics. In one paper, they included a Bridge of The Day and later added a Bridge Failure of the Day in a Bridge Engineering Class[9]. This concept grew out of using a Bridge of the Day example in Statics. But, why do engineering achievements typically get relegated to the courses where only the black-and-white aspects are examined? One of the authors' favorite examples of engineering achievement is the Brooklyn Bridge. Here, communication was *key*. Had it not been for Washington and Emily Roebling's great communication skills, we likely would not have a Brooklyn Bridge. Yet, many engineering students see the structure for itself, and do not know the backstory that was required for its success.

When the authors decided to create a 1-credit special topics class, it was decided to include engineering successes in addition to the traditional failures. While it has been pointed out that engineers do learn from failures, the instructors believed that inclusion of engineering achievements would be beneficial to the students. Instead of demonstrating only what has gone wrong in engineering history, the ability to see commonalities between the successes (such as good communication) and to contrast them with the failures and their commonalities (such as poor communication) was expected to be beneficial.

The course was developed with three topical outcomes:

1. Be aware of the impact of engineering successes and failures on the engineering profession
2. Gain an appreciation of the engineer's responsibility to society
3. Develop communication skills necessary for engineering practice

The course included in-class assignments evaluating the presentations observed (30%), their in-class presentation on a case study (40%), and a final paper (30%).

Class Structure

The class was team-taught by two instructors. Enrollment for the class was 28 students, mostly seniors. The class met once per week for 14 weeks, with the class scheduled for 90 minutes late in the afternoon to minimize scheduling conflicts. It was determined that the instructors would each present a case study of their choosing for the first three class meetings. The instructors approached the engineering faculty to see if they had a case study (either a failure or success) that they were passionate about or were interested in. Five faculty members volunteered, and had a range of case studies to present (including the History of Electrification, Kodak, the Hawthorne Effect, the Skyline Tower). One of the most popular guest speakers was an alumna who spoke

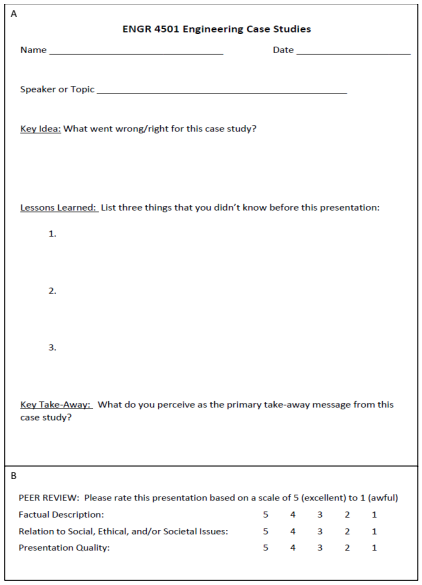
about her experiences in the real world. The remainder of the semester was dedicated to the students' presentations.

The two instructors each presented a 20-30 minute lecture on their chosen case study. In addition, there were several guests who presented a case study of their choosing to the class. Including the instructors, there were twelve presentations given by non-students (Table 1). For each of these presentations, the students filled out a simple questionnaire (Fig. 1A). In terms of instructions for hoe to effectively analyze ethical dilemmas, there were no formal instructions. However, by the time the students gave their presentations, they had been exposed to eleven different case studies presented by six different speakers.

Table 1: Presentation Topics by Guests

Topic	**Success or Failure**	**Presenter**
Kodak	Failure	Guest
Skyline Tower	Failure	Guest
Camp Lejeune Water Contamination	Failure	Guest
Hawthorne Effect	Failure	Guest
Boston Molasses Flood	Failure	Instructor
Challenger	Failure	Instructor
History of Electrification	Success	Guest
Brooklyn Bridge	Success	Instructor
Hoover Dam	Success	Instructor
Grand Canyon Skywalk	Success	Instructor
Apollo 13	Successful Failure	Instructor
Experiences as an Engineer	Failure Analysis	Guest

The students were asked to pair off and submit a case study they would present to the class. Again, they were told that the case study could be either a success or failure. The students were not given instruction in formal case study research methodology; rather, the presentations by the faculty and guests served as examples of the type of information to be presented. The student topics are laid out in Table 2. The questionnaire filled out by the students during their peers' presentations was similar to the first, but included three peer review questions (Figure 1B). The instructors also evaluated these presentations utilizing the form in Fig. 2. The final assignment was a reflection paper. The students were given basic formatting instructions: 3-5 pages, single-spaced, 12-pt font. The other guidelines they were given were that citations were not required, as they were expected to use the forms they had filled out throughout the semester as fodder for the paper, but if they utilized specific details or statistics that *should* be cited, then they ought to cite it! The content directions they were given were to reflect on what they had learned over the course of the term. The instructors purposely left the content instructions vague; it was an exercise to see *how* these students would reflect upon the semester.



A

ENGR 4501 Engineering Case Studies

Name _____ Date _____

Speaker or Topic _____

Key Idea: What went wrong/right for this case study?

Lessons Learned: List three things that you didn't know before this presentation:

1.

2.

3.

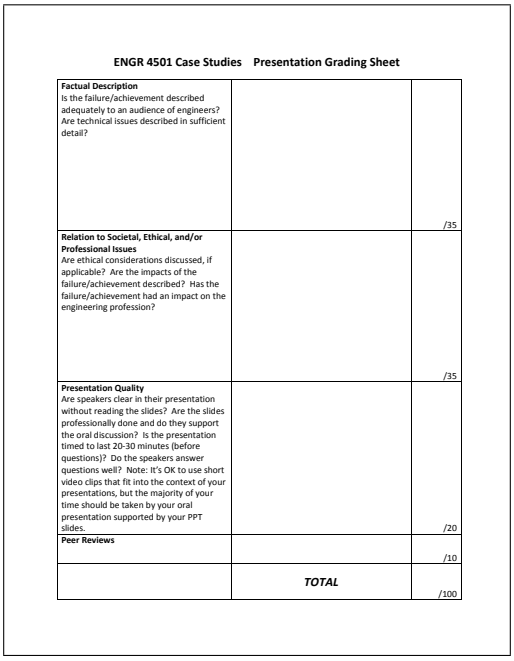
Key Take-Away: What do you perceive as the primary take-away message from this case study?

B

PEER REVIEW: Please rate this presentation based on a scale of 5 (excellent) to 1 (awful)

Factual Description:	5	4	3	2	1
Relation to Social, Ethical, and/or Societal Issues:	5	4	3	2	1
Presentation Quality:	5	4	3	2	1

Figure 1: The form students completed during (A) guest and instructor presentations, and (B) the part they also completed during student presentations.



ENGR 4501 Case Studies Presentation Grading Sheet

Factual Description Is the failure/achievement described adequately to an audience of engineers? Are technical issues described in sufficient detail?		/35
Relation to Societal, Ethical, and/or Professional Issues Are ethical considerations discussed, if applicable? Are the impacts of the failure/achievement described? Has the failure/achievement had an impact on the engineering profession?		/35
Presentation Quality Are speakers clear in their presentation without reading the slides? Are the slides professionally done and do they support the oral discussion? Is the presentation timed to last 20-30 minutes (before questions)? Do the speakers answer questions well? Note: It's OK to use short video clips that fit into the context of your presentations, but the majority of your time should be taken by your oral presentation supported by your PPT slides.		/20
Peer Reviews		/10
	TOTAL	/100

Figure 2: The form faculty completed during student presentations.

Table 2: Presentations Topics by Students

Topic	Success or Failure
Audi R18	Success
Seatbelts	Success
Titanic	Failure
Hyatt Regency Walkway	Failure
Swissair Flight 111	Failure
Liberty Ships	Failure
Millenium Bridge	Failure
Ford Pinto	Failure
Banqiao Reservoir	Failure
Hindenburg	Failure
St. Francis Dam Flooding	Failure
2010 Deepwater Horizon Oil Spill	Failure
Bhopal Disaster	Failure
Skylab	Successful Failure

Results

Despite the instructors' inclusion of engineering successes in their presentation, and their encouraging students to examine successes in addition to failures, only three of the fourteen pairs (21%) discussed a success (or successful failure). However, many of the groups **did** discuss the positive outcomes of the various failures.

Of the 28 individual reflection papers, it was interesting to see *what* the students gathered from the class. Upon analyzing the papers for some key words the instructors were interested in, Table 3 was constructed. Since there were no explicit instructions regarding the content of the paper, the instructors wanted to see if the students would reflect upon the topical outcomes of the course, in addition to the key words that either came up in class (i.e. ethics) or they have seen throughout their engineering academic career (i.e. communication).

Some of the key phrases from the students' papers are listed below:

- "Over the period of this course I've learned the importance of ethics and communication in the industry of engineering."
- "Most case studies we covered in class had failures resulting from human negligence or lack of training, design and material failures, and unsatisfactory operating conditions."
- "In our course, engineering case studies, we primarily focused on study of great achievements and historic failures in engineering, with focus on ethical issues and societal impacts. This is important because as a profession we the engineers are expected to adhere the welfare of the society we are supporting and improving."
- "Case studies of both successes and failures helps us understand common trends such as

Table 3: Occcurrence of Key Words

Keyword	Discussion/Appearance in Papers (%of papers submitted)
Success/Achievement/Accomplishments	82%
Ethics/ethical/non-ethical	71%
Safety	61%
History	50%
Communication/miscommunication	39%
Society	39%
Negligence	29%
Lifelong Learning	11%

those mentioned that either helped or hurt a project. Those trends allow us to adjust and change our views and ways of thinking towards helping to make projects not become one of the failure case studies and stay as a success, whether or not it is recognized."

- "Every class, for the most part, I was learning about something I had never heard about and the few I had, I never thought about from this point of view; the point of view of an engineer."
- "I also feel like the presentation I did in this course helped me be better prepared for the final presentation in Capstone 4010. Not only did I get practice from being assigned a presentation with a partner but also I learned a few things by being exposed to a different presentation each week. Every speaker had a different style of presentation and it was good to be able to see each presentation, take all the positive aspects of them and be able to implement them in future presentations."

In addition to examining key phrases, 46% of the students included positive remarks about the course. These ranged from simply stating they enjoyed the course to recommending the course be required for all engineering students. Again, since the content instructions were vague, the authors were encouraged to see comments such as, "As I head out into the industry, I believe that this class has opened my eyes onto what sorts of incidents can happen if things are not looked at as a whole." In addition, many of the students verbally expressed their enjoyment of the course to the two faculty members.

Discussion

At the conclusion of this survey class, a few things were clear to the two instructors: the students enjoyed the class; the faculty enjoyed delivering the class; the guest speakers enjoyed presenting and interacting with the students; and the students were able to examine engineering successes and failures to compare and contrast what went wrong with what went right. It was also clear who the favorite guest speaker was - the recent alumna.

The feedback from the students regarding the course was positive. While it was a 1-credit elective, there were suggestions from the students to consider requiring all students to take it and/or offering it to students earlier than juniors/seniors.

Without being prodded to do so, several students discussed in their reflection papers things faculty typically like them to leave college with a grasp of. They discussed lifelong learning, *without* it being listed as an outcome on the syllabus! They discussed the failures observed in class, their impact on society, and the societal impact engineers have. They were able to evaluate that while a failure was due to a failed part, that the true failure was something deeper - miscommunication, poor ethics, lax standards, or simple ignorance of putting safety first.

The favorite guest speaker - an alumna who had graduated the year prior - returned to campus to speak to the class. She spoke about failure analysis, where she is given fairly large-scale failures and needs to determine the cause. As a newly minted engineer, it was found that her visit to the class did a few things. The first was that she talked about performing failure analysis where there isn't a back-of-the-book answer and what has to be done in that case. She was interactive and enthusiastic, but most important to many of the students: *less than a year before she was in their shoes*. Unrelated to the class objectives, many students said hearing her speak about working in a field that she had never worked in before graduation alleviated fears *they* had about entering the real world.

Conclusion

In all, the instructors decided the course was successful and met its three objectives: the students are aware of the impact of engineering successes and failures on the engineering profession; they gained an appreciation of the engineer's responsibility to society; and they developed the communication skills necessary for engineering practice. In addition to achieving the course outcomes, the students and faculty *enjoyed* doing so.

References

[1] Colby, A, Sullivan, WM. Ethics Teaching in Undergraduate Engineering Education. *Journal of Engineering Education*, 97(3):327-338, 2008.

[2] Delatte, NJ Failure Case Studies and Ethics in Engineering Mechanics Courses*Journal of Professional Issues in Engineering Education and Practice*, 123(3):111-116, 1997.

[3] Haws, DR. Ethics Instruction in Engineering Education: A (Mini) Meta-Analysis. *Journal of Engineering Education*, 90(2):223-229, 2001.

[4] Herkert, JR. Engineering ethics education in the USA: content, pedagogy and curriculum. *European Journal of Engineering Education*, 25(4):303-313, 2000.

[5] Pritchard, M. Professional responsibility: focusing on the exemplary. *Science and Engineering Ethics*, 4: 215-233, 1998.

[6] Raju, PK, Sankar, CS. Teaching real-world issues through case studies, *Journal of Engineering Education*, 88(4):501-508, 1999.

[7] Richards, LG, Gorman, M, Scherer WT, Landel RD. Promoting active learning with cases and instructional modules. *Journal of Engineering Education*, 84(4):375-381, 1995.

[8] Yadav, A, Shaver, GM, Meckl P. Lessons Learned: Implementing the Case Teaching Method in a Mechanical Engineering Course. *Journal of Engineering Education*, 99(1):55-69, 2010.

[9] Nixon, W. Using History to Reinforce Ethics and Equilibrium. *Proceedings of the American Society for Engineering Education Annual Conference*, Louisville, KY, 2010.

[10] Dermody, RJ. Embracing the Past: Using Historical Structures to Teach Engineering Fundamentals. *Proceedings of the American Society for Engineering Education Annual Conference*, San Antonio, TX, 2012.

[11] MacNamara, S. The Use of Historical Precedent in Teaching Structural Analysis to Architecture Students. *Proceedings of the American Society for Engineering Education Annual Conference*, Vancouver, BC, 2011.