

Practical Ethics for Engineering and Engineering Technology Students: Assessing Ethics in the Classroom

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Abstract

Students in accredited engineering and engineering technology programs have had ethics integrated into the core outcomes of their programs since ABET transformed accreditation requirements with the introduction of the Y2K standards nearly 20 years ago. At that time, the engineering technology (ET) programs at Purdue University Northwest (PNW) implemented a simple ethics assignment into a required senior-level course based on Charles Fledderman's book, *Engineering Ethics*. The ET faculty teaching this course started noticing widespread cheating on this assignment around 2015. Dealing with this cheating issue was difficult, but it has resulted in a better learning experience for both students and faculty. This paper briefly discusses the origins of the ethics assignment in question, where and why it went wrong, and the final approach to correct the problem.

1. Introduction

Teaching ethics to engineering technology students can be a daunting task. There are many examples and case studies to share and analyze, but there is not always a definitive answer that points to one clear unethical action. The topic of ethics is complex with many facets and factors that contribute to what is considered unethical. When teaching ethics to engineering students, there is also a need to determine the difference between personal ethics and professional/engineering ethics. Fledderman defines personal ethics as dealing with how we treat others in our day-to-day lives. Engineering ethics is more narrowly defined in that it is the rules and standards governing the conduct of engineers in their role as professionals. It is a body of philosophy indicating the ways that engineers should conduct themselves in their professional capacity [1]. It is typically engineering ethics that is discussed in the ET classroom, but personal ethics may also play a role as was the case in a senior ET capstone course at PNW.

In this course, ethics is one of the major topics to be assessed as a student outcome for the course. Unfortunately, back in 2015, while attempting to assess the students' ability to apply professional ethics, the course instructor discovered that a large percentage of the class was actually engaging in a violation of personal ethics and disregarding academic integrity. The assignment focused on examination of ethics case studies and required students to write a major paper outside of class time. Having students violate academic integrity on an ethics assignment is somewhat ironic but not necessarily uncommon.

PNW is not the only place that this type of encounter has occurred. In 2015 there was also a highly publicized case at Dartmouth College that highlighted a similar issue. Sixty-four of more than 208 students were found cheating in an ethics class, “Sports, Ethics & Religion” [2]. In this situation, attendance and class participation made up roughly 15% of the student grade. The instructor noticed inconsistency in the number of students in attendance of classes and the number of student responses to answers to in-class questions using electronic hand-held clickers. Classmates of students who attended the class were having the attendees cheat for them. The instructor of the course alerted university administrators and both the cheaters and those assisting them were disciplined to varying degrees [3].

So what does it mean when students are being unethical in the classroom regarding breaches of academic integrity on assignments related to ethics? Does this mean a professor has failed to properly teach ethics, or have students simply failed to apply the knowledge of professional and personal ethics that has been shared with them? And can an instructor actually assess a student’s *ability to apply* professional ethics, or can they only assess student *knowledge* of professional ethics?

2. Applying Professional Ethics in the Classroom

ABET’s change to outcomes-based assessment for accreditation in 2000 drastically changed accreditation for most engineering and engineering technology programs. Commonly referred to as TC2K, these new requirements-based accreditation on proving student outcomes and skills upon graduation, not checklists of topics as was the previous method. Ethics were initially addressed as outcome i as follows:

Outcome i: an ability to understand professional, ethical, and social responsibilities

Later, when ABET Criterion 3 was revised, ethics was listed in outcome h as follows:

Outcome-h: an understanding of and a commitment to address professional and ethical responsibilities, including a respect for diversity

As of the 2019-2020 criteria, ethics was again included and written, this time, into Criterion 5; Curriculum: “The curriculum must combine technical, professional and general education components in support of student outcomes.” And “The discipline specific content of the curriculum must focus on the applied aspects of science and engineering and must

E. Include topics related to professional responsibilities, ethical responsibilities, respect for diversity, and quality and continuous improvement [4].

Regardless of where the topic of ethics has been written into ABET accreditation requirements, ethics has been part of the required outcomes since 2004. As an outcome, each accredited institution must prove that graduates possess knowledge of ethics upon graduation.

As PNW began to fulfill the TC2K requirements, the ET faculty decided that the best places to cover ethics were freshman and senior courses. Hence, some assignments delving into professional ethics were added to the freshman experience course, but, more significantly, assignments were added to the senior capstone course.

In the senior capstone course, Fledderman's *Engineering Ethics* was chosen as the text because it covers the history of ethics and presents numerous case studies as examples. Two class lecture periods are devoted to the subjects of ethics background and the application of engineering ethics using professional engineers as examples. The NSPE movie *Incident at Morales* is viewed by all the students as part of understanding professional ethics. When ethics topics were first initiated into the senior capstone course, after the conclusion of the background, the students were given the following assignment:

You are assigned this case study from your *Engineering Ethics* textbook by Fleddermann. Write a professional paper discussing the case. Give a brief background of the case and answer the questions at the end of the chapter on that case in narrative form. The paper should be at least 700 words long. The paper should be written in third person. Talk to a registered professional engineer about this topic. At the end of the paper, compare your opinions on the case with those of the PE. This portion of the paper may be written in first person. Submit the final paper in the Safeassign assignment.

Each student was randomly assigned one of the two dozen case studies from Fledderman's book to help insure each student did their own work. The paper was written outside of the classroom as an assignment to be turned in only after discussion had taken place with a professional engineer (PE). The final paragraph requested by the instructor was essentially a self-assessment from the student, which indicated how the student felt his/her thoughts matched with those of the PE regarding the events in the ethical case study they were assigned to read. The instructor's evaluation of student work from this assignment was based on the rubric shown in Figure 1.

This assignment worked well for several years. A number of PEs were available among the faculty for students to complete the discussion portion of the assignment, although some students used work associates. Generally, the faculty knew where the students worked, and the PE credentials submitted with the discussion portion made sense. The Safeassign system prevented plagiarism. Evaluation based on the grading rubric showed an average score between 80% and 85% for years running. Point loss on the assignment generally came from writing and grammar errors not from misapplication of ethics.

3. Identifying Papers That Are Ethically Questionable

Starting in approximately 2012, the faculty responsible for senior capstone courses began to notice the occasional expertly written paper, sometimes with numerous references, by students whose previous performance did not coincide with the final ethics assignment that was submitted. By spring 2017, it became obvious that a large percentage of students were not writing the papers that were submitted. The obvious indicators were

1. Expertly written with no English or grammar errors
2. Multiple references, frequently ten or more when the only required reference was Fledderman
3. PE credentials from off-campus PEs submitted by students who had never worked
4. Safeassign reports showed only a small percentage of copied work indicating the papers were not plagiarized

Senior Project Ethics Grading Rubric				
Name: _____				
Date: _____				
Application of Ethics to Conclusions (40 possible)				
Insightful analysis, complete understanding of principles. 40	Good understanding of ethical principles. 30	Acceptable 20	Minimal understanding. 10	Does not understand ethical principles. 0
Professionalism (40 possible)				
Perfect English/grammar suitable for any job situation, beautifully presented 40	Reasonable English/grammar that would be acceptable for most jobs, well presented 30	Just beyond minimum 20	Student did not demonstrate basic college level English skills. 10	Student did not demonstrate even basic high school level English skills. 0
Answers to Questions (20 possible)				
Well thought out, carefully considered answers. 20	All questions answered. 15	Vague relationships between questions and answers 10	Only partially answered. 5	Did not answer the questions. 0
Total (100 possible) _____				
Based on the paper submitted, this student has demonstrated a basic understanding of ethical principles: Yes _____ No _____				

Figure 1. Senior ethics assignment rubric

An example of a typical assignment submission that was questionable can be viewed in Appendix A. Upon review of Appendix A, it is easy to note that the writing style in the final paragraph where the student presents a comparison of student opinions on the case with those of the PE is very different from the writing style of the rest of the paper. Whereas the assignment instructed the student to write in third person for the first part of the assignment and allowed first person to be used for the final section of the assignment, it is obvious that the final section of the paper in Appendix A was not written by the same author of the first sections of the paper. Furthermore, the instructor is fully aware that the final section of this paper matches the typical work of other assignments submitted by this student while the first sections do not.

After some research, the instructor determined that the students with questionable assignments were purchasing papers from ghost-writers who were well acquainted with the subject matter and also with Safeassign. Studies have shown that coursework from an essay mill can pass through plagiarism checks without significant concern over its originality [5]. However, other than the obvious inconsistency in submitted work by particular students, this was only circumstantial evidence and without evidence of the source of the paper, the instructor did not feel confident that this inconsistency in work could be used as stand-alone evidence to accuse students of cheating.

4. Verifying Unethical Conduct without Hard Evidence

It is difficult to impossible to identify the author of work that is done by a ghost-writer. Unlike patch writing or copying verbatim (intentionally or unintentionally) into a paper, plagiarism detection software is not effective in catching contracted assignments [6]. The typical way that this method of cheating is identified is only by noting a shift in student writing style or enhanced quality of language as was the case in this ethics assignment in the senior capstone course at PNW.

So, what do most instructors do when they suspect cheating like this? Would they lodge a formal complaint or take matters into their own hands? *The Chronicle of Higher Education* reported that most professors say that “It’s not worth the trouble.” The judicial process can be laborious and time-consuming with punishments that do not fit the crime. This leads to many professors dealing with cheaters in the privacy of their own offices, if at all. Furthermore, there are reports of professors who have had clear-cut cases of cheating, which even included eyewitnesses, but when their university did not back their accusations, they ended up being victimized as the bad guy rather than the student, who was the one who cheated and did not get what was deserved [7].

To gather hard evidence in the case of cheating can take time, and this task is not always viewed by an instructor as a requirement of the job. So when an instructor does spend the time and effort to support a claim of academic dishonesty, it should be expected that the instructor is certain of their accusation. Accusations of this nature may sometimes result in legal actions or, at minimum, result in marks on a student’s record that can have lasting effects on a student. Unfortunately, it has been the experience of the authors that, after expending such effort on a previous issue regarding breaches in academic integrity, the outcome was not in support of the instructor accusation and the instructor faith was lost in the university system. Hence, the instructor in this situation decided to move forward with a unique approach to “catching the cheaters.”

5. Immediate Action Taken

Over the years, university support for instructors at PNW who report academically dishonest infractions by students has varied. After about 2012 it became more prevalent for the university to approach dealing with academic dishonesty cases by placing the burden to establish undeniable proof of cheating on the instructor while acting as an advocate for the student. This made it very difficult for faculty accusations of academic dishonesty to be upheld, which resulted

in cheating becoming more widespread and difficult to control. Due to this change, ET instructors realized they needed to take actions themselves to validate and control academic dishonesty when it occurred.

To combat the ethics assignment issue of ghost-writing when it was discovered in spring 2017, the instructor of the senior capstone course gave the students a surprise “quiz.” The quiz required that the students answer questions about their ethics case study in handwritten format with no Internet access and no supplemental material. The class was told if they failed this quiz, they would fail the course. But they were given one option: they could withdraw their ethics paper and receive a zero on that assignment in lieu of taking the quiz. This was a calculated bluff on the instructor’s part to identify and validate the cheating that had been going on for some time by the students suspected of using ghost-writers on their professional ethics paper. The instructor expected that students who legitimately wrote and submitted their own work would not be willing to quietly take a zero on a major assignment.

After conducting the “quiz” for two separate sections of the course, eight students out of the forty students in the two course sections withdrew their papers in agreement with taking a zero for the assignment. In addition, the instructor suspected two additional students of the same breach of academic integrity who had not withdrawn their ethics papers and gave them zeros on the assignment as well. No grade appeals were filed, which validated for the instructor that these ten students were in fact involved in contract cheating or ghost-writing. The total of students during the spring 2017 semester that were validated as cheating on the ethics paper was 25% of the students across both course sections. No further action was taken against the students. Their only resulting consequence was a lower course grade due to the zero given on the ethics assignment (and the understanding that they had been caught cheating). Had more university support been available, a different avenue would have been pursued by the instructor.

While that solved the immediate academic integrity breach, it took much reflection and discussion with other faculty to determine how to move forward with the assessment of students’ knowledge of professional ethics. In the end, the decision was made to add an altered in-class handwritten version of the ethics assignment. This approach to altering the assignment is supported by studies conducted by Medway, Roper and Gillooly, who concluded that in order to counteract vulnerability to contract cheating, higher education assessment processes need to move away from open forms of assignment-based coursework and move toward timed assessment techniques, varying assignments between classes, staged assessments and the use of oral examinations. These approaches are arguably less vulnerable to essay mill interference. These approaches require students to be present and engaged in some form of interaction to achieve the assessment outcome [5].

6. A New Approach at PNW to Assessing Knowledge of Professional Ethics

In fall 2018 and spring 2019, the ethics assignment in the ET senior capstone course was updated to require a more student-engaged method to achieve the assessment outcome related to ethics. The new approach eliminated the need for a written paper and instead simply required the student to engage with a working engineer to discuss an ethical case outside of the classroom.

The updated assignment requires verification by a credentialed working engineer to ensure the student had indeed discussed the case with them. There is then a follow-on in-class writing assignment to ensure student engagement in the process and to assess the students' knowledge of professional ethics related to the case study they read. Each time the in-class portion of the assignment is given, slightly different questions are asked, but they fall into three categories:

1. Explanation of the case – this shows if the student read and understands the incident.
2. Analysis – what went wrong in this particular incident? This shows the student's ability to analyze ethical issues.
3. Application – what should have been done? This shows the student's ability to apply ethical principles.

The updated ethics assignment states

You are assigned this case study from your *Engineering Ethics* textbook by Fleddermann. Read your case study and discuss it with a working engineer. This can be anyone with at least a bachelor's degree in engineering or engineering technology and currently working in their field. Who is at fault? What should have been done to prevent the problem? What can be done to prevent future occurrences? You must include a signed and dated statement from the working engineer with their credentials with your paper. Submissions without this will result in a zero grade on this assignment.

With the alteration in the assignment, it became apparent that the previous grading rubric did not work well with the new format. The rubric has now been updated and is shown in Figure 2. The altered rubric will be used for the first time in the fall 2019 semester.

7. Conclusion

The authors found it somewhat incongruent that the largest breach of ethics among students in their ET programs has been on the ethics assignment in the senior capstone course. Once the issue was discovered, the assignment was changed from a solely out-of-class written assignment to one that included an in-class, timed, handwritten portion. As proven by researchers at Solent University and Sabanci University [6], the change to in-class handwritten administration of an assignment has proven effective in eliminating the opportunity to be unethical by using a ghost-writer. By changing how the assignment is administered, the instructor can be assured that all answers provided by students on this ethics assignment are from their own hand.

The students can now be adequately assessed on their *knowledge* of how professional ethics should be applied, which satisfies the ABET outcome requirements for the program. This still does not mean the same thing as assessing the *application of a student's personal or professional ethics*, but that is an assessment of a different nature.

Senior Project Ethics Grading Rubric				
Name: _____				
Date: _____				
Explanation Question (30 possible)				
Demonstrates complete understanding of the assigned case. 30	Demonstrates good understanding of the assigned case. 22	Acceptable 15	Minimal understanding. 10	Did not read the case study. 0
Analysis Question (30 possible)				
Demonstrates the ability to analyze ethical principles. 30	Reasonable ability to analyze ethical principles. 22	Acceptable 15	Minimal ethical skills. 10	Did not read the case study. 0
Application Question (30 possible)				
Demonstrates the ability to apply ethical principles. 30	Reasonable ability to apply ethical principles. 22	Acceptable 15	Minimal application of ethical skills. 10	Did not read the case study. 0
Working Engineer Discussion (10 possible)				
Credential submitted as required. 10	No credentials submitted. -100			
Total (100 possible) _____				
Based on the hand written assignment submitted, this student has demonstrated a basic knowledge of ethical principles: Yes _____ No _____				

Figure 2. 2019 Updated senior ethics assignment rubric

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Appendix A

Original Ethics Assignment

You are assigned this case study from your Engineering Ethics textbook by Fleddermann. Write a professional paper discussing the case. Give a brief background of the case and answer the questions at the end of the chapter on that case in narrative form. The paper should be at least 700 words long. The paper should be written in third person. Talk to a registered professional engineer about this topic. At the end of the paper compare your opinions on the case with those of the PE. This portion of the paper may be written in first person. Submit the final paper in the Safeassign assignment.

Example of Suspected Ghost-Written Paper



Goodrich A7-D Brake
Purdue University Northwest

The case on Goodrich A7-D Brake is mainly focusing on the engineering ethics and all other surrounding fundamentals. It narrates an event from the viewpoint of a whistleblower to prove that a person with various insights on an issue can have different assumption and ideas before having a conclusion. The case talks of B. F. Goodrich Corporation, a defense contractor and how it fared on with other defense-related industries including those involved in the production of military aircraft wheels and brakes. The company was set in the 1960s in Ohio, United States of America (USA) and by 1968 it had an invention of a four-rotor brake that was to be considered lighter (Fielder, 1988). In the military, such designs required certain engineering minds, and up to now, there are still certain concepts that have to be put into place by professional engineers and other bodies to give it an illustration.

The new design of a four-rotor brake was considered lighter than the traditional one. Therefore, the only issue remaining was conducting a flight testing to qualify the design. In doing such a test, Goodrich Corporation had to show that it had a good performance on the previous series of Air Force tests (Harris Jr, Pritchard, Rabins, James, & Englehardt, 2013). Besides, a particular test had to be conducted before progressing to the final flight test. Therefore, John Warren, the design engineer handed over the design to Searle Lawson who was fresh from an engineering school to carry out the testing of the brakes (Herkert & Vincent, 1991). Lawson was first to test the potential brake lining materials that would work best with the design (Fielder, 1988). After that, various tests followed, and after six months he found that all the materials in the brakes cannot work adequately and therefore, they can never meet the Air Force's specification.

Lawson reported this to the corporation; he told Warren who then suggested a new lining material to improve the performance. However, the suggestion did not work and therefore breaks failed to pass the initial test (Petroski, 2002). It then became difficult for the company to stop pushing for the flight testing since it had been awarded a contract to supply the brakes for the A7-D by LTV. Therefore, Robert Sink, the A7-D project manager at Goodrich told Lawson to come up with a different lining that would make the design work (Fleddermann, 1999). After some time, it was discovered that setting up cooling fans at the rotors would enable the brakes to pass the test (Fielder, 1988). The Goodrich designers performed such an act even though; they were aware that having an extra cooling for the brakes was unacceptable according to the Air Force specification.

Kermit Vandivier, a technical writer for Goodrich, was assigned to write the test report concerning the new A7-D brakes. The report was to play a significant role in the Air Force decision making process. Vandivier was not an engineer, but he had the knowledge in writing such types of tests. While writing the report on A7-D brake tests, he noticed that some of the test results had been doctored to meet the Air Force specification (Weil, 1981). He raised the relevant concerns claiming that it was wrong to write the report using a falsified data. In response, the management told him to proceed with the report, and at the end, the report was very satisfying since it met all the specifications required. The brakes were, therefore, qualified for flight testing.

On the other hand, Vandivier felt guilty for abandoning his legal responsibility (Manion, & Evan, 2001). He then contacted his attorney who said that he and Lawson might be convicted for committing a conspiracy to conduct fraud.

Vandivier and Lawson contacted the FBI who then began investigating the issue. After some time the case reached the Senate and was put into a hearing. Nonetheless, every strategy to get to the bottom of this issue failed, and at the end, no official action was taken to Goodrich. In fact, most of its employees did not experience any adverse impact on their careers (Weil, 1981). The case study, therefore, asserts how an organization can commit an engineering fraud and fail to be held accountable. In analyzing the case, I consulted Walter L. Elden, a professional engineer. Elden emphasized on the Codes of Ethics governing the engineers (Basart & Serra, 2013). He mentioned three vital responsibilities of engineers that were omitted by Goodrich Corporation and its staffs. First, an engineer must hold paramount the safety, health, and welfare of the public. Second, the engineers must avoid deceptive acts (Fielder, 1988). Finally, any professional engineer must issue public statements in a truthful and objective manner.

Many questions can arise from the case, for instance, it can be asked whether an unethical act was taking place when the tests results on the brakes were falsified. It is true that an unethical act was taking place and this can be justified through the code of ethics guiding the Engineers (Van de Poel & Verbeek, 2006). According to the case, it can be seen that Goodrich Corporation was never planning to redesign the brakes, they only wanted to proceed with the A7-D project (Cruz, & Frey, 2003). In designing the brakes, they claimed that the new model could not be tested using the old test methods and so they ought to have as well invented a new test procedure.

In conclusion, Goodrich exhibited a sloppy management in the whole process, and this can cause an ethical implication of a deceptive act. It can also be seen through the acts of Vandivier since he was not ordered at gun point to make such a report. He was not to be deceived by the management (Glendon, Clarke, & McKenna, 2016). To prevent the case from gaining public attention, Goodrich ought to have listened to Lawson. They were to discredit the whole invention instead of using it to attain the A7-D contract (Mitcham, 2015). Besides, by accepting the deal, they never considered the safety, health, and welfare of the people. The engineering field demands for trustworthy and honest professionals who are accountable for their acts.

Comparison of student opinions on the case with those of the PE

I went to professor Neff and we talked about my topic, which was about Goodrich A7-D Brake. And he discussed with me what happen to that company and how they faced that problem with government. So, they did big problem which was the quality of the break wasn't good. And the FBI knew about that since the company needs to be up front with them. It seems like the company dishonest with the data to the government. But, the company already knows what happened to the break. After that the government gave them a chance to fix the data and retest the break on specific time. Well the company was willing to do that and they did it on the time and redesign the break with good quality. Here what I learned engineer should be honest and

done nice work and be sure what are doing and who they dealing with the companies or customers

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