



## Using Creative Writing as a Tool for Learning Professional Development in Materials Science and Engineering

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## Abstract

Courses in professional development can be a catch-all to address student skill building in areas such as technical writing, communication, career path reflection, and ethics. While each of these skills is important to student development, the application of ethical thought in a professional development course can be challenging. In our program, we have traditionally taught ethics from the perspective of engineering case studies (such as the Ford Pinto case or the Bhopal disaster). Students have traditionally been asked to write executive summaries and participate in debates regarding these well-documented and dissected cases. The content and related assignments have been considered separate from the career path agenda that is also part of the course. While student feedback has been favorable, the goals of our program include ensuring that students can apply ethical decision-making, rather than solely reflect on historical case studies. To bridge the cognitive and affective domains, we have implemented the use of student-written novellas. We hypothesize that students exhibit internalization of ethical values by placing themselves in a future “self-oriented” situation. Students selected the physical setting and timeline for their self-written novella; the primary stipulation was that throughout the novella, the main character (the student) would be required to make a series of decisions that required ethical analysis. Throughout the written assignment, which spanned 10 weeks, the instructor would offer writing prompts related to each student novella to infuse additional ethical situations into the product. Instructors and graduate students then applied a rubric assessing the application of ethics and compared the results to those from a traditional series of assignments from a previous offering of the course. In addition, students were surveyed to reflect upon their experiences in the course and their understanding of ethical principles. Rubrics and surveys were developed to probe both the cognitive domain (understanding of ethics) as well as the affective domain (applying decision-making in new, unfamiliar scenarios). We will present on these data as well as the structured approach for the assignment.

## Introduction

Professional development courses can serve to assist students with critical skill development in professional behavior. Ethical decision making is one key example of professional behavior, yet the pedagogy of ethics can be challenging to implement. Case studies have been used as a best practice in most textbooks and have been cited as being highly effective in training students to think about the consequences of engineering action. Existing case studies are often then augmented by “What if” essays, student debates, and other activities targeted at development of the affective skills associated with ethics in engineering.

Ethics is an extremely important topic for engineers at every level and field. Engineers should be held to a very high standard, as the decisions we make can impact large populations in ways that are difficult to predict. The National Society of Professional Engineers outlines the ethical codes, with a preamble that engineers “require honesty, impartiality, fairness, and equity, and must be dedicated to the protection of public health, safety, and welfare.” Safety is paramount; decisions related to design/fabrication/maintenance of engineered systems could result in major loss of life and personal freedoms if we put profits and personal advancement before the well-being of mankind. While this framework is obvious to engineers trained in areas that have an obvious

human connection; students trained in Materials Science and Engineering, who generally do not sit for a Professional Engineering license, cite a disconnect between the NSPE code of ethics and their perceived future experiences. While many case studies, both modern and emerging (Bhopal and Flint, MI as two examples) can be learned through the lens of materials science and engineering, students are still required to make several leaps of logic to find the connection.

Writing in engineering curricula is not new; many organizations continue to call for more breadth in the liberal arts education. Unfortunately, challenges with rising tuition costs, limitations to four-year programs, and increasing specialization of fields and faculty limit the ability to programs to meet the needs and desires of all constituents. However, without an ability to think outside of themselves, which is often provided by a robust liberal arts education, young engineers will be at a disadvantage in solving the new, undefined problems of the world. Thus, creative thinking, fictional literature, history, and other fields should, at the very least, be integrated and interwoven into engineering coursework. Thus, to effectively interweave ethics training and creative thinking, we used writing assignments to achieve the objectives of the professional development course. We hypothesize that the use of creative writing, coupled with traditional case study analysis, will increase student understanding of ethical theories and increase student ability to apply critical thinking to ethical scenarios.

## Course Structure

The course where this method was applied is taken by Materials Science and Engineering students. The class generally has approximately 20 students. The students are typically in their 2<sup>nd</sup> or 3<sup>rd</sup> year of university coursework. Until this course, the coursework is largely related to technical skill building and materials theory. Students often approach the course with hesitation, as it is fundamentally different from any other course they have had the opportunity to take as engineering students. The course spans a 16 week semester. The first 2 weeks are focused on resume and cover letter writing, as well as interviewing skills. The Career Services office is heavily leveraged in these assignments. Students are required to attend the Career Fair, held the third week of classes; this aids in the awareness of career types and opportunities ahead.

In Week 3, students are introduced to ethical theory. Utilitarianism, Golden Mean ethics, Rights ethics, and Duty ethics are all discussed. “What if” statements are used to aid in student understanding of how these theories apply to engineering. Week 4 introduces the first case study in engineering ethics. Typically, for the class in question, the Bhopal disaster is the first case studied in depth. Students will prepare case study reports, applying each ethical theory to the case. Students are then further asked to identify what could/should have been done differently. Students are encouraged to examine cases from all angles, as is common in ethical analysis.

In Week 6, the students were given the creative writing assignment. This assignment is shown in Figure 1. This assignment was initially intimidating to students. However, all 18 students in the Fall 2019 cohort scheduled a meeting with the faculty member in charge of the course within 1 week of being given the assignment. There were four scheduled checkpoints during the writing phase, which lasted 10 weeks. The checkpoints allowed for an informal, qualitative assessment of student progress, as well as a formative opportunity to prompt students with respect to ethical

decision making. Seventeen students ultimately completed the assignment successfully (one student left the university mid-semester due to a family emergency).

Figure 1. Novella Assignment in Engineering Ethics

What is a novella?

It's basically a short novel. The working definition is:

- 1) A complete story with a beginning, middle, and end
- 2) ~ 15,000 words
- 3) Simple plot line
- 4) Two point-of-view characters at most

I want you to write about yourself, or from your perspective. I want you to place yourself in the future – this can be 5 years, 10 years, 15 years – whatever you choose. You may elect to include a chapter that describes your past and how you got to be where you are in your story. Then, think about where you want to be, what you want to be doing... It can be in any voice you choose. The timeline of your story is flexible, it can be as short as a day, or as long as a lifetime.

You can take inspiration from books, movies, videos – what is your favorite TV series or favorite movie? Any given TV episode or movie generally could be considered a “novella”. Place yourself in the episode as one of the characters. What decisions would you make differently?

Most importantly – don't panic. This is meant to get you thinking about your future and the type of engineer/human you hope to be. You will not be graded on your story-telling ability, your grammar, punctuation, etc. (Although, please try to write it in a way that makes sense). I will not grade you on the “correctness” of the choices you make, as long as the argument for the choice is reflected.

This component will be worth 25% of your overall grade. It will be graded based on:

- Author addresses “big” decisions using an ethical decision-making process
- Author identifies how they want to influence their slice of the world (and this slice can be geographically wide or very narrow – it's your story)
- Author identifies how materials science (your academic background) helps guide your decisions and life goals.

Key elements of this story:

- 1) It should highlight your professional career and the choices you make. These may be influenced by your life choices (ex. family), but the primary storyline should revolve around your professional life.
- 2) It should include “big” decisions that impact your employer, society, the environment, etc. “Big” does not mean earth-shattering (unless you see yourself in a role that would indicate global leadership), it means impactful. Impact can be as simple as choosing to put a water cooler in the main office of a Materials Science Department to cut back on the continued waste stream of plastic water bottles. The theme should be around sustainability, ethics, morality, etc.
- 3) It should be inspired by people/places/etc. that inspire you. As an example, I'm truly inspired when I stand on the trail leading into the Grand Canyon. My novella would probably include a moment of reflection as I hiked into a really, really big hole in the ground.
- 4) It can include elements of your life up until this point. Don't feel like it can't draw on you, as you are today. In other words, there is usually some degree of reality in fiction!

## Results and Discussion

Students were asked to complete an entry survey and a post-course survey. The questions were the same from Fall of 2017 through Fall of 2019. In Fall of 2019, additional questions were added to the post-course survey to assess the efficacy of the novella. The pre-survey results are shown in Figure 2. Generally, no statistical differences are seen class to class. Students believe that materials science is important to society, are semi-confident in their ability to make engineering decisions, and are neutral on their understanding of ethical theory. Students are trained prior to this course in decision making related to plagiarism and scientific experimentation, thus it is expected that they feel confident in these skills.

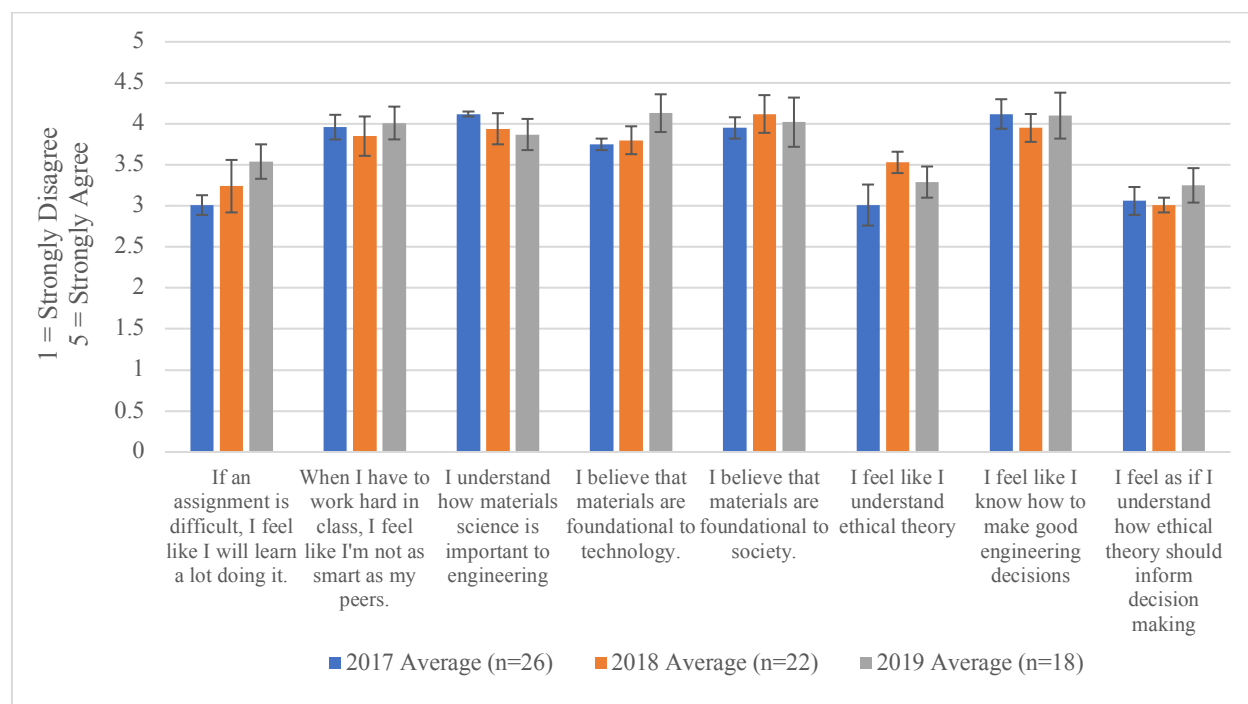


Figure 2. Pre-Survey results. All students completing the survey are students majoring in Materials Science and Engineering.

The post-course survey results are shown in Figure 3. Across the years, student self-perceived achievement is relatively consistent. Of particular note, however, is the question related to how ethical theory informs decision making. In 2019 (the year of the Novella), the scores in this question are significantly higher than previous years ( $p < 0.01$ ). While this cannot yet be directly attributed to the novella assignment, given multiple interacting factors, it is an observation that warrants future analysis in courses.

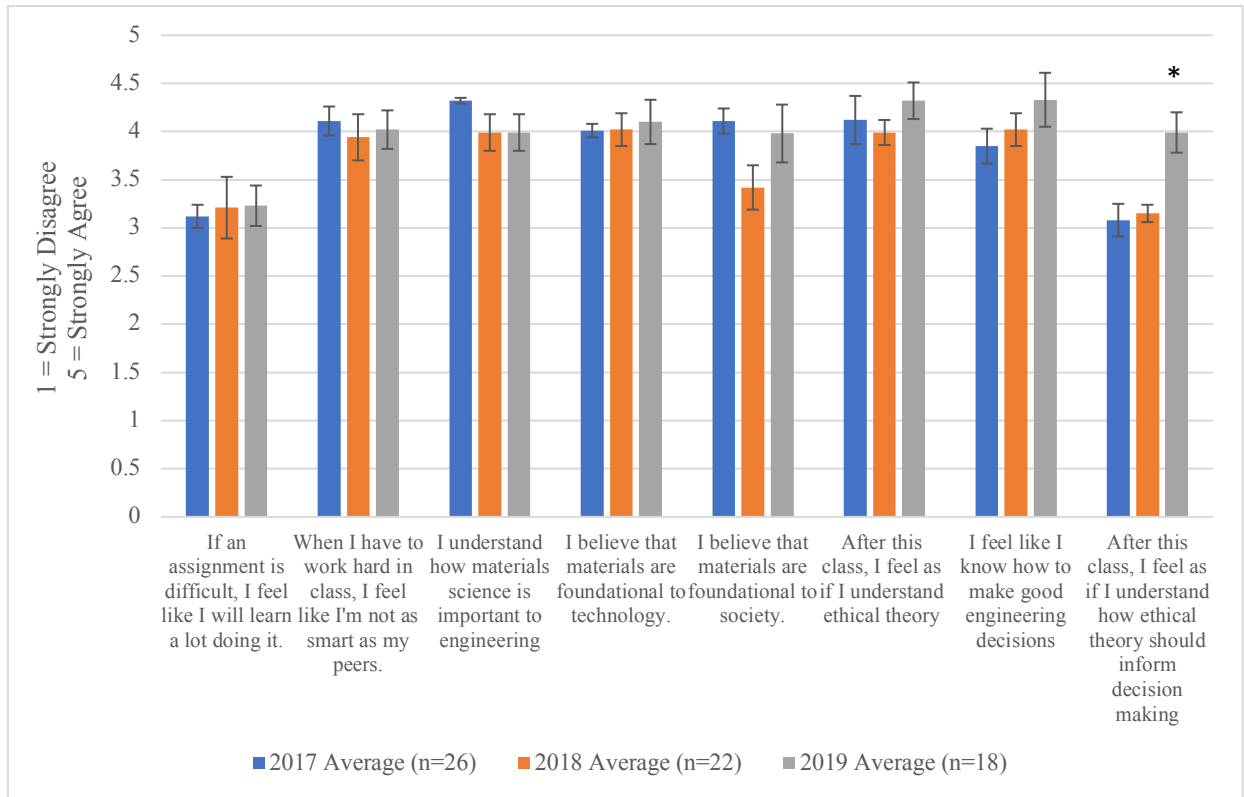


Figure 2. Post-survey results. All students completing the survey are students majoring in Materials Science and Engineering. \* $p < 0.01$

Table 1. Raw change in student response from Pre-Survey at beginning of 16 week period to Post-Survey at end of 16 week period.

	Change in Student Responses from Pre to Post		
	2017	2018	2019
If an assignment is difficult, I feel like I will learn a lot doing it.	0.11	-0.03	-0.31
When I have to work hard in class, I feel like I'm not as smart as my peers.	0.15	0.09	0.01
I understand how materials science is important to engineering	0.2	0.05	0.12
I believe that materials are foundational to technology.	0.26	0.22	-0.03
I believe that materials are foundational to society.	0.16	-0.7	-0.04
I feel like I understand ethical theory	1.11	0.46	1.03
I feel like I know how to make good engineering decisions	-0.27	0.07	0.23
I feel as if I understand how ethical theory should inform decision making	0.02	0.14	0.74

To examine the changes from the pre-survey to the post survey, comparative student responses are shown in Table 1. While not all responses can be absolutely attributed to one class, of note is the significant increase in the response related to the last question. Students perceive themselves to be better at ethical decision making in the 2019 class. While this cannot be directly attributed to the addition of the novella, it presents an interesting point of view. The novella structure was designed to have students fictionally place themselves in ethical dilemmas. Perhaps the personalization of the novella allowed for students to reflect more deeply on decision making than a traditional “post-case” case study assignment might. This being said, the course in both the traditional assignment structure as well as with the addition of the Novellas achieve the goal of increasing student understanding of ethical theory.

The impact of different assignments was also assessed in survey form (Figure 3). Students perceived most of the assignments as highly useful. Of particular note is the response per year related to case studies aiding in the understanding of the relationship between ethics and materials science. In 2019, students reported a significantly higher confidence in their understanding of how ethics and materials science are connected via use of the case studies. This could indicate a change in perception of each case study, as most case studies were used as prompts in the writing and continuous feedback of the novella assignment.

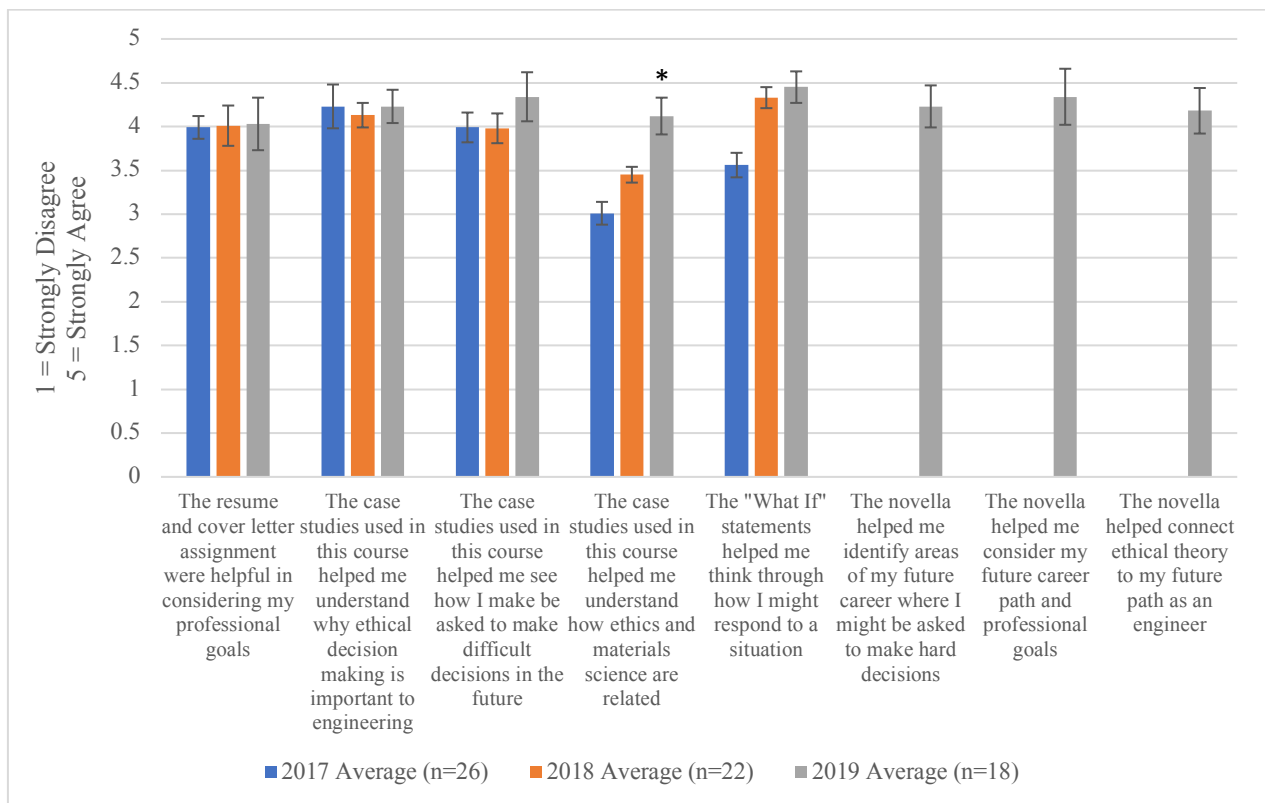


Figure 3. Survey results related to assignments in the course. Students generally find all assignments helpful, although case studies do show a significant improvement from 2017 – 2019.



## Future Work

All assessment performed to compare traditional ethics courses with the course where a Novella assignment was added to personalize both professional development and ethical principles was indirect. While assignments were grading, assignments have not been compared using a robust rubric to understand how student perception and decision-making capability (at least on paper) has evolved throughout the courses. This rubric will be under development for future permutations of the course and assignment. Overall, the addition of the novella did not detract from the core learning objectives of the Professional Development course; in many cases, it appears that students may have internalized more content due to this element of personalization. As this was a first pilot of this type of creative writing assignment in an engineering course, more data will be necessary to fully understand how the integration of liberal arts directly into engineering courses will influence engineering mindset in students.