Behavioral Ethics and Engineers: Factors Affecting Decision Making in Cases Involving Risk and Public Safety

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Abstract

Traditional approaches for infusing ethics into engineering curricula emphasize a Rationalist model. In this approach, student learning is focused on understanding and recognizing ethical issues and developing better reasoning skills. To guide ethical decision making, students practice determining facts, clarifying concepts, identifying relevant ethical principles, and weighing evidence. While developing better reasoning skills is critical, research suggests that a person's judgement is also affected by a host of social and psychological factors occurring throughout the decision making process. This paper explores how the ethical decision making of engineers can be improved through a better understanding of these social and psychological factors (so-called "Behavioral Ethics"). To this end, Behavioral Ethics was introduced into a senior engineering design course in Civil Engineering and a freshman introductory course to examine ethical questions centered on issues of risk and public safety. To guide the identification of learning outcomes, a Behavioral Ethics rubric was developed which outlined key attributes for recognizing how social and psychological factors may influence awareness of ethical issues, judgement, as well as the ability to undertake an ethical course of action. A Behavioral Ethics module was developed which included lecture materials and case studies. A class activity was developed based on the classic Ford Pinto case study in which students read narratives of engineers involved and identified how specific cognitive, situational, or institutional factors may have influenced their decision making. Nearly all freshman students (92%) were able to identify a factor in at least one behavioral area (cognitive, organizational or situational) and over half (56%) were able to identify a factor in all three areas. All the senior-level students were able to identify at least one factor in each of the three areas. The results show that case studies like the Ford Pinto can be effective for developing understanding about how social and psychological factors may influence ethical decision making.

Introduction

Engineers are confronted with ethical challenges on a daily basis, from navigating conflicts of interest to negotiating duties to clients and the public. Major engineering failures, such as the Challenger disaster and the Hyatt Regency walkway collapse, are tragic reminders of the consequences when short-cuts are taken or responsibilities avoided in the profession of engineering. Engineers involved in construction are faced with navigating one of the most corrupt industries globally. In fact, the American Society of Civil Engineers (ASCE), citing a study by Transparency International, indicates that $850 billion, or 10% of global construction expenditures, are lost to bribery, fraud, and corruption each year [1].

The engineering profession recognizes the importance of ethics through establishment of ethical codes of conduct. Every major discipline of engineering has an established "Code of Ethics." The engineering profession also demonstrates a commitment to ethics education through the

ABET outcomes criteria (a-k). The ABET student outcome "(f)," in particular, requires graduates have an "understanding of professional and ethical responsibility." The revised ABET student outcomes (1-7) have similar language, namely "an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments …" The ASCE "Body of Knowledge" echoes the ABET criteria and states that "civil engineers … need to demonstrate an understanding of and commitment to practice according to the seven Fundamental Canons of ethics…" [2]. The National Academic of Engineering emphasizes one of the important attributes of the "The Engineer of 2020" is "high ethical standards and a strong sense of professionalism" [3].

The traditional approach for infusing ethics into engineering, and most textbooks on engineering ethics [e.g., 4, 5, 6], emphasize a Rationalist model [for a review of curricular interventions see 7]. In this approach, student learning is focused on understanding and recognizing ethical issues and developing better reasoning skills. The traditional approach emphasizes the historical traditions of ethical thought (e.g., utilitarianism, deontology, and values), engineering codes of ethics, decision making processes (e.g., "line drawing"), and case studies. To help improve ethical decision making, case studies are used to allow students to practice important steps in the decision making process, such as determining facts, clarifying concepts, identifying relevant ethical principles, and weighing evidence.

While this approach strengthens students ability to understand, analyze and evaluate ethical issues, research suggests that a person's judgement is also affected by a host of social and psychological factors occurring throughout the decision making process [8, 9]. Cognitive biases, such as "ethical fading," "framing," "incrementalism," and others, are mental shortcuts that influence our reasoning, evaluating, and remembering. Social and organization factors, such as an "obedience to authority" or "group think" (i.e., conformity bias), can also affect our decision making. Finally, situational issues, such as time pressure or fatigue, also can play a role in impacting our decisions.

Despite the significance of these psychological and social factors, little attention has been paid to them in the context of engineering ethics education. Psychological and sociological factors have received some mention in classic engineering ethics case studies. In the Challenger disaster [10], for example, the engineers from Morton Thiokol initially recommended against the launch but after a meeting with NASA management reversed their position. While this has generally been considered as an example of engineer's ethical responsibility, the potential factors behind this reversal have been less discussed. Cases like the Challenger disaster and others suggest a better understanding of the behavioral issues affecting our decision making is warranted.

To this end, this paper explores how the ethical decision making of engineers can be improved through a better understanding of these social and psychological factors (so-called "Behavioral Ethics"). Said a slightly different way, we are exploring how this knowledge -- i.e., understanding how engineers actually *behave* when faced with an ethical dilemma -- can be used to improve the ethical development of engineers. This work builds on previous studies on the

application of Behavior Ethics in the fields of Business and Law [11,12,13]. Behavioral Ethics integrates traditional educational approaches to ethics with personal and professional reflection (i.e. what moral foundations do we and our profession bring to an ethical decision), an exploration of biases and stumbling blocks (e.g., loss aversion, ethical fading, etc.), and an emphasis on developing effective habits and strategies to avoid these decision making pitfalls. These insights can be applied at both the personal and institutional level.

This paper describes the introduction of Behavioral Ethics into an engineering curriculum, using ethical questions centered on risk and public safety as an example. To guide the identification of learning outcomes, a Behavioral Ethics rubric was developed which outlined key attributes for recognizing how behavioral factors (i.e., cognitive, situational and institutional factors) may influence awareness of ethical issues, judgement, as well as the ability to undertake an ethical course of action. A Behavioral Ethics module was developed which included lecture materials and case studies. An activity was developed, based on the Ford Pinto case study, in which students read narratives of engineers involved and identified how specific cognitive, situational, or institutional factors may have influenced their decision making. An assessment was carried out in order to evaluate the extent to which students were able to learn these concepts.

A "Behavioral Ethics for Engineers" Rubric

Shuman et al. have developed a rubric for engineering ethics, the so-called Pittsburgh-Mines (P-M) Engineering Ethics Assessment Rubric [14]. The P-M Rubric identifies five main attributes, including recognition of the dilemma, information, analysis, perspective, and resolution. A student's ability for each attribute spans from Level 1 to Level 5. The ability to recognize a dilemma, for example, may be non-existent (Level 1) to being able to "clearly identify and frame an ethical dilemma (Level 5). The attribute of Information relates to the students ability to identify key pieces of information related to the decision and make assumptions where information is missing or limited. Analysis is a measure of the rational decision making skills of the student and the student's ability to look at a situation in depth considering the full complexity of the situation. Perspective relates to the students ability to look at the situation from multiple points of view. Finally, Resolution refers to the ability to come up with alternatives for action and with justification based on the consequences of each. The cognitive, situational and institutional factors described above may influence all of these attributes.

In the field of Business, a four component framework for ethical decision making developed by James Rest has been adopted to explore concepts in Behavior Ethics [11]. The four components include awareness, judgement, intent and action. Each of the four components can be impacted by the cognitive, situational and organization factors described above. Awareness refers to the ability to recognize a moral or ethical issue and the relevant standards or principles that apply to the situation. Cognitive, situational and institutional factors may play a role in determining a person's sensitivity to a moral or ethical issue or how intense the person perceives the issue to be.

Judgement refers to the capability to apply rational decision making to the ethical question or dilemma. The P-M Rubric most closely aligns with these first two components, awareness and judgement, in the four component framework of Rest. As noted above, judgement involves identifying relevant facts and principles, defining conceptual issues (e.g., what constitutes a bribe?), analyzing the situation, and developing and evaluating alternatives. Similar to awareness, cognitive, situational and institutional factors may influence all of these activities.

Intent and Action are generally not represented in more traditional rubrics for engineering ethics, but at the same time, play an important role in determining a course of ethical behavior. Intent refers to the degree to which an individual is committed to a moral course of action and depend on an individual's personal moral intuition, identify and affect. Action involves the ability to translate awareness, judgement and intent into action. Again, the different cognitive, situational and institutional factors described above may influence both a person's intent and action.

With these concepts in mind, different levels of learning behavioral ethics, for awareness through action, can be considered, from an "emerging" understanding (Level 1-2), to "developing" (Level 3), and "maturing" and "mastering" (Level 5). The rubric in Table 1 illustrates the levels of knowledge with respect to behavioral ethics. An emerging understanding, for example, would be characterized as having only cursory knowledge of some elements of human behavior and how behavioral factors may influence one's own awareness, decision making and action. A student with a developing understanding would recognize "red flags" and how behavioral factors may be influencing one's own decisions and begins to apply strategies to avoid pitfalls. Mastery would involve recognizing "red flags" and very consistently and effectively applying strategies to improve decision making.

Table 1. A Behavioral Ethics for Engineers Rubric (Note: the levels correspond to the five levels of development in the P-M Engineering Ethics Assessment Rubric. Levels 2 and 4 are omitted for brevity). Note, "behavioral factors" refers to the cognitive, situational and institutional factors influencing behavior.

Attribute	Level 1	Level 3	Level 5
Awareness	• Does not recognize behavioral factors that may influence one's sensitivity • Does not recognize how behavioral factors may influence how one may perceive the moral intensity of a situation.	• Recognizes behavioral factors may influence the ethical sensitivity of the individual • Recognizes how behavioral factors may influence how individuals perceive the moral intensity of a situation. • Begins to apply strategies to overcome pitfalls	• Clearly identifies behavioral factors that are influencing one's sensitivity • Clearly recognizes how behavioral factors influence ones perception of the moral intensity of the situation. • Consistently applies strategies to overcome pitfalls
Judgement	• Does not recognize how behavioral factors may influence ethical decision making and judgement	• Recognizes how behavioral factors may influence ethical decision making and judgement • Begins to apply strategies to overcome pitfalls	• Clearly recognizes how behavioral factors may influence ethical decision making and judgement • Consistently applies strategies to overcome pitfalls
Intent	• Does not recognize how behavioral factors may have influenced formation of one's moral intuition, identify and affect	• Recognizes how behavioral factors, most specifically organizational or situational, may have influenced formation of one's moral intuition, identify and affect	• Clearly recognizes how behavioral factors, most specifically organizational or situational, may have influenced formation of one's moral intuition, identify and affect

		• Begins to apply strategies to overcome pitfalls	• Consistently applies strategies to overcome pitfalls
Action	• Does not recognizes how behavioral factors may influence moral ownership • Does not recognizes how behavioral factors may influence a sense of moral efficacy • Does not recognizes how behavioral factors may influence moral courage	• Recognizes how behavioral factors may influence moral ownership • Recognizes how behavioral factors may influence a sense of moral efficacy • Recognizes how behavioral factors may influence moral courage • Begins to apply strategies to overcome pitfalls	• Clearly recognizes how behavioral factors may influence moral ownership • Clearly recognizes how behavioral factors may influence a sense of moral efficacy • Clearly recognizes how behavioral factors may influence moral courage • Consistently applies strategies to overcome pitfalls

Course Materials

To explore how concepts in Behavioral Ethics can be taught in the context of engineering, a number of course materials were developed as listed in Table 2. Lectures covering basic content related to engineering ethics in general, and Behavioral Ethics in particular, were developed. These lectures provided an overview of engineering ethics as well as more detailed information about particular ethical issues such as public safety, global issues, trust, corruption, conflicts of interest, as well as rights and responsibilities in the workplace. With this background, additional information on Behavior Ethics was provided.

Table 2. Curricular Materials Developed in Support of Learning of Behavioral Ethics

Material	**Description**
Lectures	• Introduction to Engineering Ethics • Risk and Public Safety • Global Issues • Issues of Trust • Rights and Responsibilities in the Workplace • Overview of Behavioral Ethics • 1-page summary of cognitive, organization and situation stumbling blocks
Case Studies/ Discussions/ Assignments	• Ford Pinto • Flint Michigan • Hyatt Regency Walkway Collapse

The lecture materials were aimed at providing students with a basic knowledge (e.g., "recognizing" and "understanding") of issues related to engineering and behavioral ethics. The case studies, discussions and assignments, on the other hand, were aimed at helping students develop higher order skills related to the topics, such as "analysis" and "evaluation." Additional details on the case studies, discussions, and assignments will be provided in the next section which summarizes the assessment of specific learning outcomes.

The Ford Pinto Case Study shown in Table 2 focused particularly on understanding the cognitive, situational and institutional factors that may have played a role in this tragedy. Students were given an article entitled "The Engineers Lament" which appeared in *The New*

Yorker in 2015 [15]. "The Engineers Lament" was selected for this assignment because it included an extensive interview with one of the engineers at Ford Motor Company, Denny Gioia, who was involved in evaluating the crash data for the Ford Pinto. Students were provided the article and asked to identify specific cognitive, situational or institutional factors that may have played a role in the decision making regarding the Ford Pinto. Students were required to identify direct quotes or other information from the text to support their answers.

Assessment of Learning Outcomes

Selected materials were utilized for two different civil engineering courses: a senior capstone design course and a freshman introduction to civil engineering course.

Senior Capstone Design Course. The year-long, senior capstone design course had an enrollment of 13 students. Each of the students had already taken a required 3-credit course in engineering ethics. Approximately 4 weeks of the spring semester of the course were devoted to engineering ethics. Each week, the class went over 1-2 lecture topics, as described in Table 2. Lectures were followed up with assignments and in-class discussion of particular cases and problems. The Ford Pinto case study was presented to the students and assessed as a homework assignment and counted approximately 3% toward their final course grade. An in-class discussion of the case occurred after the students had submitted their homework.

Students in the senior design course were asked to identify one cognitive, organizational (i.e. institutional) and situational factor that may have played a role in the Ford Pinto case. All thirteen student were able to successfully identify at least one factor for each. Table 3 shows an example of a student response for each of the three different behavior factors: cognitive, organizational, and situational. Students identified, for example, how as a recall officer Denny Gioia only received a typed, double-side sheet of paper with photos to evaluate a case. A similar case, the Ulrich crash, was much different in that much more personal details were available. The "Tangible and the Abstract" bias refers to how people place more emphasis or weight on information that is tangible, compared to more abstract information. The students were able to correctly identify how this bias may have played a role in how Denny Gioia evaluated the recall case. The students were also able to identify organizational factors by highlighting how Denny Gioia went to work at Ford to try to change the culture, but "got flipped within the space of two years." This was identified as an example of an organization factor, such as Obedience to Authority or Conformity Bias. The students also recognized situational factors, such as the Time Pressure Denny Gioia was under.

Table 3. Examples of student responses in senior capstone design course for Ford Pinto assignment

Factor	**Evidence**
Tangible and the Abstract (cognitive)	"The Ulrich crash is what led to Ford's being charged with homicide. It is also very similar to the Pinto case that had come across Denny Gioia's desk five years earlier: a rear collision, leading to a fire. In

	Gioia's case, however, the kinds of detail that made the Ulrich case so emotionally compelling—the three girls, the volleyball game, the melting sunglasses, Judy Ulrich's cry for help—were absent. He had a typed double-sided sheet, with photographs. That's what a recall officer sees."
Obedience to Authority or Conformity Bias (organizational)	Gioia says he went to Ford with the idea that he would "fight them from the inside," but sooner or later, inevitably, the world that surrounds us, all the working day, takes precedence. "Here's the guy that went in with a strong value system, with intent and purpose, and got flipped within the space of two years," he went on. "If it could happen to me, it could happen to anybody."
Time Pressure (situational)	"Gioia could get twenty to twenty-five reports a day. The pace was unrelenting. Everything was a crisis."

At the conclusion of the course, students were given an Exit Survey which assessed their understanding of the concept of Behavior Ethics in general, and two factors in particular, incrementalism and loss aversion. All the students were able to correctly remember these key concepts.

Freshman Introduction to Civil Engineering Course. This course had 39 students, none of which had taken a course on engineering ethics. Therefore, this was the first exposure the students had to engineering ethics in general, and professional ethics in particular. Also, only one lecture was devoted to the topic of engineering and behavioral ethics.

Like the Senior Design students, the students in the freshman course were also asked to read "The Engineers Lament" as a homework assignment (again the assignment was about 3% of their final course grade). The freshman were asked to answer three questions related to Behavioral Ethics:

1. Identify at least one cognitive factor, situational factor, and organization factor that may have played a role in the Ford Pinto case. Be sure to provide quotes or other information from the text to support your examples. Attached is a "Behavioral Ethics Cheat Sheet" to help you identify possible stumbling blocks in the text.
2. Give a few examples of things you can do personally to help yourself avoid the stumbling blocks encountered by engineers at the Ford Motor Company?
3. What types of policies or procedures might a company like Ford institute to help prevent cases such as the Ford Pinto?

The first question was similar to the question provided to the senior capstone design class and assessed a more basic understanding of the concepts. The latter two questions, however, aimed to assess a higher level of learning. The goal of these latter two questions was to test whether students could synthesize the case and what they had learned about Behavioral Ethics to identify strategies they could implement, either personally or within organizations, to avoid behavioral stumbling blocks.

Table 4. Results for question 1.

Exemplary	Satisfactory	Developing	Unsatisfactory
… is able to identify more than one relevant stumbling block for each of the areas (cognitive, situational, and organizational)	… is able to identify at least one relevant stumbling block for each area (cognitive, situational, and organizational)	… is able to identify at least one relevant stumbling block for at least one of the areas (cognitive, situational, or organizational)	… is not able to identify at least one relevant stumbling block
6	16	14	3

The assessment results for question 1 showed that a little over half (56%) of the students were able to correctly identify at least one relevant stumbling in each of the three areas (cognitive, organizational, and situational). Students were able to identify a number of cognitive stumbling blocks, including framing, rationalization, tangible and the abstract, loss aversion, ethical fading and the self-serving bias. As an example, one student noted the potential for framing or rationalization with the quote from Denny Gioia that "you have to accept that, if you're a manufacturer who's building a product like a vehicle, people are going to get killed. With respect to situational factors, students identified the transparency of the process and time pressures. Social or organization factors identified by the students included conformity bias and obedience to authority.

Table 5. Results for question 2.

Exemplary	Satisfactory	Developing	Unsatisfactory
… is able to identify more than one personal habit that will help prevent a stumble for each area (cognitive, situational, and organizational)	… is able to identify more than one personal habit that will help prevent a stumble for one or more area (cognitive, situational, and organizational)	… is able to identify at least one personal habit that will help prevent a stumble for one or more area (cognitive, situational, and organizational)	… is not able to identify at least one personal habit
0	7	21	11

The results for question 2 indicated the students were less able to synthesize the concepts and come up with specific habits or actions that could be used to prevent behavioral stumbles. Only about 18% of the students were able to come up with a personal habit that would prevent a stumble in one or more areas. However, some students were able to come up with potentially effective habits or actions, such as getting multiple perspectives on a problem, seeking feedback from someone not directly involved, maintaining a personal code of ethics, developing a script beforehand about who to handle different situations, setting a time to reflect on decisions,

identify a mentor, seeking more information whenever possible, and trying to be as transparent as possible.

Table 6. Results for question 3.

Exemplary	Satisfactory	Developing	Unsatisfactory
… is able to identify more than one organizational policy that will help prevent a stumble for each area (cognitive, situational, and organizational)	… is able to identify at least one organization policy that will help prevent a stumble for each area (cognitive, situational, and organizational)	… is able to identify at least one organizational policy that will help prevent a stumble for at least one area (cognitive, situational, and organizational)	… is not able to identify at least one organizational policy
5	10	18	6

Question 3 asked students to design an organizational or institutional policy to prevent stumbles. About 38% of the students were able to identity one or more policies for each area. Students suggested organization policies or actions such as requiring transparency between different units of the organization, establishing criteria that automatically trigger review up the chain of command (e.g., a fatality), seminars on time management, an anonymous hotline, ensuring sufficient staffing, leadership training, and the idea of assigning a team to argue any counter proposals.

Discussion

This paper explores how Behavioral Ethics can be introduced into an engineering curriculum, with a specific case study focused on the issue of risk and public safety and the Ford Pinto. The materials were introduced into two courses: a senior capstone design course and a freshman introduction to civil engineering. The senior design students were able to recognize, understand and apply concepts from behavioral ethics to the case of the Ford Pinto. In a brief exit survey, the results suggest that the students developed a general understanding of the meaning of Behavioral Ethics and some of the types of cognitive stumbling blocks that can influence ethical decision making.

A more involved assessment was carried out for the freshman course. In this case, the students did not have as much of a background in engineering ethics and only received a very short overview (1 lecture) of engineering ethics in general, and Behavioral Ethics in particular. However, almost all the students had at least a developing understanding of the basic concepts and could identify at least one stumbling block in the Ford Pinto case study. A little over half the freshman students had a satisfactory or exemplary understanding of stumbling blocks. Fewer students were able to synthesize the lecture and case study and come up with personal habits they could use in order to avoid stumbling blocks. Trying to identify institution policies was also more difficult for the students compared to identifying specific stumbling blocks in the Ford

Pinto Case. However, a number of students were able to propose some potentially effective personal habits and policies to help avoid cognitive, organization and/or situational stumbling blocks.

It should be noted here that a limitation of the study is that no assessment was carried out to determine the level of understanding of these concepts before the lecture material was presented and case study completed. Therefore, these results assume that the students had little formal understanding of how cognitive, situational and institutional factors influence ethical decision making, especially in a professional context.

In relation to the rubric presented in Table 1, the results suggest more traditional curricular materials, such as the lectures, case study, and assignments described here, can be effective at helping students learn concepts related to behavioral ethics, especially for the rubric areas of awareness and judgment. Being able to apply these concepts to better understand one's own intent and action, however, is more challenging. To this point, traditional curricular materials may not be as effective. Instead, students will likely need to synthesize the concepts presented here with personal reflection, perhaps by examining ethical stituations they have faced as students and looking at how cognitive, situational and/or institutional factors may have affected their behavior.

The concepts and results presented here complement work focused on exploring a broader understanding of professional ethics and ethical behavior. The work presented here, for example, builds on the concept of "moral imagination" as a "means of understanding (of self, others, institutions, cultures), for reflective criticism, and for modest transformation…" [16]. The process of moral imagination may indeed be a valuable tool for recognizing and overcoming psychological stumbling blocks. Our understanding of the biases we bring to ethical decisions has been informed through the concept of "Moral Foundation Theory," or the idea that there are a handful of key moral foundations that serve as the building blocks by which different societies and cultures construct a shared moral intuition [17]. The main foundations include care, loyalty, fairness, liberty, authority, and sanctity. Examining the American Society of Civil Engineers Code of Ethics, for example, show the foundations of care, fairness, loyalty and authority are highlighted to a greater extent than issues around liberty or sanctity [18].

Conclusion

A rubric and curricular materials were developed focusing on introducing concepts of Behavioral Ethics in engineering. Students, both freshman and seniors, were able to fairly quickly understand and apply concepts in Behavioral Ethics to cases in engineering. Seniors with a background course in ethics and greater focus on the topics were able to more completely grasp and apply the concepts. However, even a majority of freshman students, with assumed little or no knowledge of the concepts before a brief lecture, were able to apply the concepts successfully. Traditional course content, such as lectures and case studies, appear to be effective to enable student learning of Behavioral Ethics, especially aspects related to awareness and judgement.

Additional aspects of ethical behavior, such as intent and action, however, may require these types of course materials be supplemented with activities that promote personal reflection.

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