

Worcester Polytechnic Institute

An Investigation of Engineering Behavioral Ethics

DT Badley

Behavioral Ethics Interactive Qualifying Project 2019-2020

Prof. Harold Walker

Table of Contents

Introduction	3
Introduction to Behavioral Ethics	4
Factors that Affect Ethical Decision Making	7
Established Behavioral Ethics in Professions	12
Behavioral Ethics Survey	17
Introduction	17
Methods and Anticipated Results	17
Data and Analysis	20
Case Study: FIU Bridge Collapse	26
Introduction	26
Key Participants:	27
Chronology of Events	28

Introduction

More than 500 billion dollars on average are lost in the field of engineering in a year due to corruption. (Addressing corruption, NAE) Whether it be cutting corners on safety features to avoid costs or workers cutting corners to avoid more work, unethical decisions can be catastrophic to both employees and consumers alike. Not only can these unethical decisions lead to harm, they can also lead to jail time depending on how bad the outcome of the decision was. One way to help battle unethical decision making is to educate those going into the workforce of the factors that can cause making an unethical choice. By doing this, they gain the opportunity to recognize unethical situations and know how to react accordingly.

Behavioral ethics is the study of how people make ethical or unethical decisions. It is an interdisciplinary field drawing from other fields such as psychology, cognitive science, evolutionary biology, and philosophy. Behavioral ethics differs from philosophy by not focusing on how people should ideally behave but rather why people behave the way they do. (Behavioral Ethics, ethics unwrapped) Studying behavioral ethics is to study the innate, subconscious factors that influence the decisions that people make daily such as in the workplace. By educating people about these factors, it is hoped that the number of unethical decisions in the workplace can be reduced. It was found that after just a single behavioral ethical training session, workers behaved more ethically or tried to act more ethically after two years. (Warren)

In this paper, a review of behavioral ethics will be done detailing the general factors identified in the research literature that can affect decision making. After that, a review of how behavioral ethics is applied to workplaces such as law, business, and engineering will be

explored. Then, the paper will delve into the survey performed by this IQP to gain quantitative and qualitative data regarding behavioral ethics in regards to professionals and students alike. The last part of this paper is a case study investigating the 2018 Florida International University pedestrian bridge collapse, and the behavioral factors that may have had a role in the situation. The FIU bridge collapse was a tragic, avoidable accident that claimed the lives of six and injured ten more. (NYTimes) It is a recent example of how factors such as groupthink can be extremely dangerous in an engineering setting.

Introduction to Behavioral Ethics

When discussing morality, philosophy, specifically ethics, was used by using abstraction and introspection while actual human behavior was all but ignored (Herbert Gintis). The field of ethics is the field of systemizing, defending, and recommending concepts of right and wrong behavior. (ethics, Internet Encyclopedia) While ethics is a vast field with many niches depending on the field it is employed, there are four common philosophical principles that relate to ethics: autonomy, beneficence, non-maleficence, and justice. Autonomy is latin for “self-rule”, and it states that people have an obligation to respect the decisions made by other people concerning their own life. Beneficence is the concept that there is an obligation to bring about good in all of our actions, and similarly, non-maleficence is the concept of not purposefully doing harm to others. Lastly, justice refers to the concept of the obligation to give others what they are owed and to treat everyone equally. (Mnstate) These concepts are the fundamental principles to which many ethical schools of thought such as value, deontology, relativism and teleology revolve around. Ethical relativism is the concept that morality is relative to the environment or culture a

person is brought up in. For someone in this school of thought, there aren't universally known moral standards, but rather, the morals depend on how society functions. Teleology is the concept that things are defined by the reason or purpose they are to be used. For example, a baby's intrinsic telos would be to become a child, or a spoon's intrinsic telos is to be used to drink liquids. There are also four common philosophical traditions that can also relate to ethics; deontology, utilitarianism, virtue ethics, and rights ethics. Deontology, or duty ethics, is the theory that the rules dictate what is right and wrong. It is often associated with Immanuel Kant who introduced the concept of categorical imperative which is the central concept of deontology (Kant, Immanuel, 1785). Deontology is the concept that people should not lie, steal, or cheat no matter the circumstances. It stipulates that it is the duty of the individual to follow the rules. (Springer) Utilitarianism is a concept that one should take actions to maximize the happiness and well-being of affected individuals. (Duignan, Brian, Utilitarianism) Virtue ethics is primarily concerned with traits and attributes of character that are essential to human development and flourishing, not with the innate duties. (Britannica, Virtue Ethics) Rights are claims against others to be treated in certain ways no matter what. Rights claims that everyone has the innate duty to respect others rights. (Santa Clara University, Rights)

Engineering has its own set of ethics. However in engineering, there is a code of established ethics that may vary depending on the specific field of engineering such as Civil Engineering, Electrical Engineering, and Mechanical Engineering. Despite this, there are six general canons listed by the National Society of Professional Engineers that apply to all forms of engineering: to hold paramount the safety, health, and welfare of the public, to perform services only in areas of their competence, to issue public statements only in an objective and truthful

manner, to act for each employer or client as faithful agents or trustees, to avoid deceptive acts, and to conduct themselves honorably, responsibly, ethically, and lawfully so as to enhance the honor, reputation, and usefulness of the profession. These canons have various codes that further specify how to apply the canon in particular situations. When being taught engineering ethics, students are taught the rationalist model which emphasizes recognizing ethical issues and developing better reasoning skills (walker finalpaper). The use of case studies such as the Ford Pinto case, Apollo 13 case, and Space shuttle Challenger case are used to identify However, the way engineering ethics is currently taught focuses more on what is right and wrong and less on the reasons why people make decisions they know are wrong. By teaching behavioral ethics, students could have a better understanding of not only what is right and wrong, but also, they could have a better understanding.

Behavioral ethics focuses on human behavior in regards to how it affects decision making. It is accepted that the individual may understand that a choice is immoral, but they still might make the immoral choice anyway. (Herbert Gintis) For example, the trolley problem is a classical philosophical problem that could distinguish between the concepts in ethics and behavioral ethics. It is a famous ethical hypothetical situation that describes a set of scenarios regarding pulling or not pulling a lever to save people. Usually, the answer to how one should act aligns with their school of thought, but from the perspective of behavioral ethics, it wouldn't necessarily matter what they choose, but instead, why they chose what they did. In essence, the difference between behavioral ethics and ethics is that ethics cares about the right answer, and behavioral ethics, while still interested in the right answer, is more concerned about the factors that may have led to the decision that they made.

Behavior is defined as how one acts or conducts oneself, especially toward others.

(Webster) Many factors can affect how one behaves such as the environment one grew up in, socioeconomic standing, mental state, and the social setting or environment you are currently in are three or four general factors that affect behavior. The current behavior of a person, in turn, can greatly affect how they go about making decisions. For example if one person was given the choice of vanilla ice cream or strawberry ice cream on a Tuesday, they would choose the strawberry ice cream because that is their favorite flavor, but if the same person were given the same choice when they were with all of their vanilla loving friends, they may choose vanilla in order to avoid conflict. In this simple example, conformity played a major role in the decision of the person presumably with little to no interaction with the choice they would have made other than the choices others made. In a sense, each choice has a probability that is weighted by the factors that favor it being made. For example, someone is more likely to make unethical decisions while alone and more likely to make ethical decisions when surrounded by peers. While there is a chance they still may make ethical and unethical decisions respectively, the factors negatively influence the chances of the other decisions. Much of the field of behavioral ethics is on the research of these factors and how to prevent unethical decisions by informing people of them with the hope being that once people are informed about them there is a better chance they will take that into account while making the decisions. Going back to the probability analogy if the person making the decision were to know that by being alone they will more likely make an unethical decision, they will probably take that into consideration when making an ethical decision. In the next section, ethical decision-making factors such as conformity will be further explored.

Factors that Affect Ethical Decision Making

Many factors can affect the way decisions are made. From situational, social, and cognitive, there are always factors that affect decisions. Situational factors are those that arise depending on the context of the ethical decision such as the environment. Social factors are those that deal with social pressures or expectations that may affect the person's behavior. Cognitive factors are innate mental stumbling blocks that occur when people do not think rationally. In this section, a review of many of the factors that affect decision making will be presented and supported with evidence.

The self-serving bias is the tendency for people to claim responsibility to positive events that happen in their lives but to blame external factors on negative events that happen to them. An example of this would be a student who has a high grade in a class but failed their most recent test because they didn't study for it. They would attribute it to their cleverness when they had a good grade in the class, but they would blame the test for being too hard or the teacher for not teaching well enough. In 1970, a study was done by Beckman had a group of teachers teaching a group of young children. The study ended up finding that whenever the students would do well, they would attribute it to themselves, but when they would do bad, they would attribute it to the teachers (Beckman 1970). This study along with others is what formed the basis of what would become the self-serving bias theory.

In-group out-group bias is when an individual favors people in their peer group or individuals socially similar to them compared to someone they would perceive to be outside their peer group or social circle. An example of this would be a boss giving their friend a raise or

promotion in spite of another worker outside of their friend group deserves it more. It is a well-known phenomenon that affects many decisions daily. A study was published by Efferson, Fehr, and Lalive in 2008 that made participants play cooperative games. The game had the participants choose partners to cooperate to make decisions. (coevolution) Based on whether or not they could cooperate, they were rewarded or punished. They found that people tended to form in-groups and subsequently those in-groups would favor each other in social interactions.

The overconfidence effect is when an individual perceives their actions to be more ethical than how ethical their actions are. (texas) For behavioral ethics, the facet of the overconfidence effect that is of interest is the overestimation effect which describes an individual having too much certainty in their ability or level of control. This may manifest in an individual making plans for the future only to have overestimated their ability and not being able to accomplish the task.

The concept of the slippery slope is a fallacy used in many fields such as politics, psychology, and philosophy. The gist of the argument typically used by someone invoking the term is that a negative small action may cause a chain of increasingly negative action. An example of a slippery slope would be a person drinking a cup of coffee one day which causes them to get coffee every day. Until, they are addicted to coffee and need it to not get headaches. While the slippery slope is a logical fallacy in some fields, it is a factor in behavioral ethics.. An example of this would be someone lying to their peers, so then because of that lie, they keep telling bigger more extravagant lies to cover for the first lie. Another classical example of this would be a professional taking a small gift once, then taking larger and larger gifts until it affects the decisions they make in their work. Neuroscientists at the University College London's

Affective Brain Lab ran an experiment where they put eighty people in scenarios where they could repeatedly lie. Based on the magnitude of their lies, they would get paid more. They claimed that this was the first evidence that the more people lie, the bigger the lies get. (nature)

The bystander effect says that people are less likely to act to help someone or intervene in a situation, the more people are there. The bystander effect was one of the main drivers behind the formation of behavioral ethics being formed. One of the prime examples of the bystander effect was the murder of Kitty Genovese in 1964. She was killed in the night time pleading for help, but no one came to her aid despite there being 38 witnesses. (independent) One of the key reasons for the bystander effect is the concept of diffusion of responsibility. When there are more people, they expect others to step in to intervene because of the number of people there. However due to the fact everyone is thinking someone else will step in, no one intervenes. Interestingly enough, it has been found that if someone is directed to step in, then they are usually more than willing to once they are singled out. In an experiment done by Bommel in 2012, 86 students were put into an internet forum where they could either choose to help or stay silent regarding 5 distressing stories. Some of the participants were red and some were black, The red participants could be seen by the other participants while the black participants were anonymous. The study found that the black participants didn't nearly act to help as much as the red participants did which sides with the bystander effect. (bommel psynet)

Another factor someone different from the bystander effect but relates to this same study is the spotlight effect. The spotlight effect is the tendency for individuals who believe they are being observed to act more ethically than they normally would. A common example of this behavior is whenever people slow down whenever they see a police car, even if they were

speeding. The study done by Bommel could also confirm this effect as well because the red participants, in the study, would probably have acted similarly to their counterparts, the black participants, if they were also anonymous, but due to the fact they were not publicly presented, they tended to act more unethically.

Obedience to authority is when an individual is willing to do something unethical simply because an authority figure instructed them to do so. Typically, the main reason people are willing to go along with the instructions is due to the risk of punishment. People try to avoid negative stimuli at all costs, so in light of that, they are willing to act in ways they normally would not. Another side being, people tend to assume authority figures have more technical knowledge in the subject than them, so they may blindly follow their instructions assuming they must know what they are talking about. An experiment tied to obedience to authority would be the famous Milgram experiment. The experiment was designed like so. Participants were designated to be instructors to other “participants”(an actor) by asking them a series of questions. Whenever the actor would say a wrong answer or didn’t answer in the right amount of time, the participant was instructed by a scientist in a white lab coat to deliver a shock to the actor and increase the voltage. The study showed that people followed the scientist’s instructions despite giving what would have been lethal shocks to a human simply because an authority figure instructed them to do so. (simple psychology)

Conformity is when an individual takes cues on how to act based on a group rather than using their insights. For example, if everyone is wearing a certain shirt, an individual might question why they are not wearing that shirt and go find one. It is the need to fit in with the group that drives conformity because people do not typically want to stand out. A famous

experiment done by Asch in 1951 shows this concept. The experiment had 50 students participate in a sight test. In each exam, an individual student would be surrounded by 6 “test takers” who were actors. The group was shown a vertical test line and three different vertical lines with their task being to identify which of the three lines matches the test line. The group was instructed to point to the line they believed to be correct. The actors were instructed to always choose the wrong line that was wrong. The study found that 32% of the participants chose the wrong line to stick with the group answer. (asch, psynet)

While conformity by itself may not necessarily be an unethical thing, when paired with ethical fading it can be very dangerous. Ethical fading is when a culture of unethical actions takes root in a group over time. For example, if students systematically cheated on exams by giving each other answers. In this situation, it may have started with two students, and as time went on, it became ten students. Eventually, the culture of the class would involve it being morally acceptable to cheat on the exams. Suppose there was an exceptionally bright student in this class who had not cheated, this student may feel pressured by his peers to either give answers for them or may rationalize their actions to do it because everyone else is doing it.

Groupthink is a concept in behavioral ethics and psychology that involves a group trying to use conformity to avoid conflicts within the group. Due to the desire to minimize conflicts within the group, it may come to a decision that is not critically analyzed. The first thoughts to be suggested may be the ones implemented simply because raising other thoughts may cause conflict. Overall, groupthink leads to a lack of creativity and independent thinking. It is a factor that will be explored more in-depth further in the paper in the FIU bridge collapse case study.

Established Behavioral Ethics in Professions

Business ethics is an important subset of ethics due to the impact unethical behavior in business can have on the lives of billions. However, the traditional way business schools teach their students on how to act rationally regards teaching students to identify how decisions are made and the ethical steps to take to make the right decision. While the rational method has been used as far back as ancient Greece, behavioral business ethics has begun to be used to not only identify ethical situations and rational steps that must be taken, but it is also used to identify cognitive, environmental, and social factors that might affect their decision-making process. In the next section of this paper, examples of traditional business ethics such as products that are morally right or wrong in business, protecting the customers from bad business practices, and protecting employees will be given with a behavioral ethics spin to them.

Just because there is a need does not mean certain things should be sold. Organs, sexual services, and surrogates are all illegal for sale due to the potential for harm they may have on those selling and being sold to. While there is certainly a demand for each of those services, they each have the potential to have people preyed on or used in ways that are not right. However, others protest this method of thinking and instead see it as unethical for people to not be allowed to use what is theirs to make money. For example, take college student W, W is a poor college student who needs to make money to pay for rent. A rich man B with terminal kidney failure needs a replacement kidney to save his life and offers W \$100,000 for his kidney. W could use that money to pay his rent and pay off his college debt. W has no family history of kidney failure, and he is in perfect physical health. In the rational method, which might lead to these

people going to the black market where they may be further put into danger than if the government made it legal and regulated these practices in safe places. A behavioral factor that might be in play affecting the lawmakers' decisions would be incrementalism or slippery slope because they fear that if this case is allowed, then it could lead to the poor being preyed on for their organs. In the case of these three, the government has made them illegal, but what about other products that are dubious but legal, where should the line be drawn?

The business world has taken a Kantian approach when approaching consumers of people always being an end and never a means. (wiley, kant) In other words, consumers should be treated with respect and dignity instead of doing whatever you can to make them buy your product. An example of this would be falsely advertising that a product could reduce their chance of getting cancer or could make them look a certain way when it cannot. However, if a company is trying to stay competitive in a market where claims like these are made regularly, they might feel pressured to make unethical decisions when they know it is wrong because everyone else is doing it. This is a prime example of conformity because the company would otherwise not have considered using these false advertising methods, but due to the fact everyone else is doing it, they do it as well. Another consideration for the customer that isn't just unethical but illegal is when competing companies agree to fix their prices to higher prices. In these cases, the companies tend to be selling in a market with high barriers to entry making it hard for anyone else to compete meaning customers have no choice but to pay which is another example of conformity in business. Product safety is another key issue that businesses have to contend with. For example, business owner X works at a firm that sells toys. They have a deadline to make, but they haven't finished fully testing the toy for safety. Their ad campaign that has millions of

dollars invested in it stated the toy will come out by their deadline, and if they were to push it off they would lose millions. The ethical answer would be to hold it off, but business owner X's would probably send the toy out anyway. This is an example of time pressure affecting the decisions negatively because, ideally, if the business was given enough time it would have tested the product. The previous example is the reason why there are organizations such as the FDA and FTC to help protect customers from faulty or dangerous products.

The treatment of employees is another major area of business ethics. In a study done by Glassdoor, 61% of employees feel they had been discriminated against for their race/ethnicity, gender, sexual preference, and age. (glassdoor) Despite even from the day they are first interviewed, employees (or potential employees) have certain ethical rights that should always be upheld. For example, let's say there is a manager who has a choice between two potential employees. The first employee has shown that he could be a valuable addition to the team due to their vast experience and knowledge of the field, but the employee is a friend of the manager that is down on his luck and looking for a good job. It would be unethical to not hire the most qualified person, but the manager might feel the need to help out his friend who is in his ingroup compared to the other potential hire that is in his out-group. Another ethical concern is how much should one employee get paid over another. Should they both get paid equally no matter what, or should they get paid based on the work they do? Both paths of thought are used by business and both have their problems, but the ethical concern is how people use either system to act unethically. For example, a boss gives higher pay to their friends and lower pay to their enemies.

It has been found that a business that has a climate of acting ethically tends to have employees who act ethically. (Cairn, ethical climate) One that teaches its employees on the factors they may be faced with and reward those that call out unethical action instead of firing or ostracizing these individuals helps alleviate the perceived need to act against what they know to be true. On this same note, unethical behavior should be punished in a manner equal to the action done. Actions like these could be a way companies avoid ethical fading from occurring within their businesses and ensure ethics are an integral part of their climate.

Engineering behavioral ethics uses similar concepts as business behavioral ethics to try to try to understand the behavioral factors that affect the ethical decisions people make in an engineering environment. Since engineering firms are also businesses, most business behavioral ethics can be applied to the operation of an engineering firm, but it differs in the service being done which falls under the engineering code of ethics for that field. Usually, businesses have a product that they are trying to market and sell while engineers perform some sort of service or design of products. With engineering being a 267.4 billion dollar industry in 2019, there are millions of engineering projects that happen every year with a substantial amount of them being able to severely injured people if they aren't carried out correctly. (ibisworld) The study of engineering behavioral ethics tries to improve on engineering ethics by looking into the factors of why people failed to live up to those ethics which may have failed the product and injured people. In the next section of this paper, insights from engineers and engineering students in their workplaces will help to give context on reasons why these choices may be made.

Behavioral Ethics Survey

Introduction

As discussed above, there are many factors that can affect decision making and, by proxy, can affect the ethical decisions made in daily life. While it is simple to understand how these concepts may affect someone theoretically, real world examples from practicing engineers and engineering students may confirm that these phenomena may affect not only anyone but confirm that these concepts can happen in any situation. To try to identify real world examples from practicing professionals and engineering students, a survey was conducted which had 36 participants contribute their experiences in an engineering setting. The participants were asked to recount experiences where an ethical decision was to be made and to reflect on what may have made them make the choice. The survey was designed to be open ended to account for the diversity of potential factors that may have affected their decision. Two main objectives of this survey are:

1. To confirm that choice behavioral apply to the decisions made by engineers in an engineering setting
2. To see what behavioral factors may cause or lead to other behavioral factors affecting decision

Methods and Anticipated Results

There are four major types of surveys that can be conducted by a researcher: questionnaires, interviews, cross-sectional surveys, and longitudinal surveys. (Sincero, explorable) Questionnaires are typically administered on pen and paper or online. It consists of a list of questions, typically closed-ended, that aim to gather information from many participants in an objective fashion. They are advantageous for obtaining objective data, but questionnaires typically lack context for the information provided. Interviews are the polar opposite of questionnaires because they are typically conducted in-person on a 1 to 1 basis. Interviews are typically more probing in nature due to the conversational aspect of the survey. One of the key aspects of an interview is that it allows the researcher to ask key follow-up questions which may give more insight than if the questions were being answered through a questionnaire. However, interviews are time-consuming and requires the researcher to individually meet with and question each participant. Cross-sectional and longitudinal surveys both have an aspect of time to each, for they either look at the views of individuals at a certain time or over a period of time. It was decided that neither of these types of surveys were required for this study.

Throughout the course of the study, the dilemma of the best method of collecting relevant data concerning behavioral factors in an engineering setting was a major hindrance. On the one hand, questionnaires lacked the appropriate context needed to truly get an understanding of the problem, but they would allow for quantifiable data. On the other hand, interviews would allow for much of the context needed to get a full grasp of the situation which would allow for

determination of the factors in play, but due to time constraints, there would only be a limited amount of participants. Over the course of two months, a survey was developed that would take aspects from questionnaires and interviews that would hopefully get quantifiable data whilst getting context into the situation the participant was in to try to identify relevant behavioral factors. This is achieved by asking open-ended questions that ask the participant to describe times they had to make an ethical decision. If the question did not apply to their experiences, then they were instructed to answer the question with “N/A”. It is assumed that if a participant answers the question with an example of an experience that they’ve had, then it would function similarly as a “yes” in terms of quantifying response later in data analysis.

Question 1	Describe a time you ever felt you were treated unfairly because an authority figure was closer friends to another group of peers? How did this impact you and your work?
Question 2	Describe a time you’ve done something with others that you would normally never do alone? Now describe a time you stood up against others doing something unethical. What was the difference in the situations?'
Question 3	Describe a time there was a gray area in instructions given to you that would allow you to exploit them?
Question 4	Describe a time you cut corners due to lack of sleep?
Question 5	Describe a time where, from your perspective, you were doing the right thing, but when you learned more about the situation, you realized it was the wrong thing?

Question 6	Describe a time you've made a bad decision because an authority figure pressured you to not lose something(i.e. money, materials, time spent doing something, etc)
Question 7	Describe a time where you were being rushed and let something go that you normally wouldn't?
Question 8	Describe a time you submitted work that you knew wasn't up to your standards? What factors may have played a role in that?
Question 9	Describe a time where there was widespread negative change overtime at your job/school that started from one small action?
Question 10	Describe a time you were in a group and didn't voice opinions about an idea to avoid conflict?

Table 1: List of Questions

The first question aims to touch on the factor of obedience to authority figures in regard to in-group-outgroup behavior. As shown above in the literature review, both factors have been proven to affect ethical decisions, but this question aims to gain insight on how the two affect each other when in the same situation. A follow-up question then asks the participant to relay how it affected them and their work which should give their conclusion of the experience. The conclusion can then be used to determine whether the factors either or not the factors had an effect on their behavior.

The second question aims to determine whether conformity had an effect on the participants' experiences while in an engineering setting. The follow-up question tries to see at

what point did they draw the ethical line in sand. The purpose of this question is to see how influential the factor of conformity is to the participant and the ethical limit it can take them to.

The third question simply aims to try to better quantify the self-serving bias by asking the participant about a time they abused a “gray area” in a set of instructions.

The fourth question tries to ascertain whether fatigue has played a role in ethical decisions made by the participant, in particular cutting corners in work.

The fifth question aims to see if ethical fading is a factor that has affected any of the participants’ decisions in an engineering setting.

The sixth question is similar to the first question because it is comparing the effect of loss aversion on the factor of obedience to authority.

The seventh question aims to ascertain whether time pressure has affected the participants’ decision making.

The eighth question varies from the other questions because it directly asks the participants what factors they think made them rationalize their behavior in a time they submitted work that was not up to their standards. This question was made in the hopes it could insights to how the participants’ view their own actions and give context to their knowledge of behavioral ethics.

The ninth question addresses incrementalism or slippery slope in regards to the engineering setting they were in.

Lastly, the tenth question directly addresses specifically groupthink in an attempt to see how if that is a factor that has had an effect on the participant’s experiences.

The demographics of the survey mainly consists of students at Worcester Polytechnic Institute as well as professionals in the field of engineering. The survey gave each participant four questions from those listed above as well as two questions to establish demographics. This

was done to gain data on a wide range of factors while not being too time intensive for the participant. In the next section, the results from the survey will be analyzed.

Data and Analysis

Figure 1: A pie chart showing the demographics of the participants

The survey was taken by 36 individuals who consisted of 27 students and 9 professionals as shown in figure 1. It took the average participant 21 minutes to complete the survey, not accounting for those that did not fully complete their entry. As stated above each participant was given four questions randomly from the list above. However, of the ten queries, questions 5, 9, 11, and 13 were the only ones with enough responses to be statistically relevant enough to analyze.

Figure 2: A bar graph indicating the results of the survey

From the above data shown in figure 2, it can be ascertained that question ten and eight had the most significant impact with 72.7% and 84% , respectively, of participants who received that question having been in the relevant situations. These results indicate that the situation is fairly universal throughout the field of engineering. Then, questions two and six had 38.9% and 42.1% of participants who received the question indicate that they've had these particular experiences. These results would indicate that these experiences occur frequently. In the following section, a more detailed discussion of the data for the four questions will be done.

The second question primarily aimed to determine whether conformity had an effect on the participants' experiences while in an engineering setting. Of the responses that were counted, it seemingly had the lowest effect on decisions made by the 18 participants that received this

question with only 7 of them stating they've been in a similar situation. Admittedly, most also found the question to be vague or didn't understand what it was asking which may have impacted the results of the question. However, this result would indicate that conformity can play a role in certain ethical decisions of an engineer. Most participants who usually had the factor of in-group out-group deciding whether they acted or not such as in this response:

“One time a friend of mine was talking badly about another person on our team (i didn't really like this person either), so I started to also talk badly about him. One time a person I knew was using the R word several times, so I finally was like, “stop it that's really not nice to keep saying that.” The difference was that in one situation I had the same opinion as someone else even though that opinion was mean, and the other time was a situation where I would never use that word so I felt like I should say something”

As shown above, the participant seemingly acted more ethically when they perceived the person to be in their out-group, in this case the out-group being those who use the “R word”, and they acted less ethically and conformed to the group mostly because it pertained to an individual they didn't like.

The sixth question's purpose was to see the effect of loss aversion on the factor of obedience to authority and to confirm if loss aversion could exacerbate obedience to authority's effect on ethical decisions. Of the 19 participants who responded, 8 of them stated they have had a similar experience meaning 42.1% of the 18 participants have been pressured by an authority figure due to loss aversion. One response that highlights the effect on loss aversion on obedience to authority are:

“On IQP, my group worked on providing ideas that would be implemented by a company hired by our sponsor. Since the company and our sponsors didn't want us to suggest ideas that would take too much time/money to implement, we were too cautious in our suggestions and abandoned any large changes we had considered. This prevented the development of many possible ideas/improvements.”

As shown above, in an attempt not to lose time or money the company restricted the ideas the participant's group had and “prevented the development of many possible ideas/improvements.” While it is not unethical to not work on those ideas, it showcases how loss aversion caused the authority figure in this case to direct them in a manner that could have been unethical which would have exacerbated the factor of obedience to authority.

Question eight had the purpose of having the participant self-report a factor that may have contributed to a time that they submitted subpar work. It was found that out of the 25 participants given this question, 21 have submitted work, at some point, that they knew was subpar with 18 of them citing time pressure as the main factor that drove them to do it.

“Times I have submitted work that wasn't up to standards came down to the limited resource of time. I decided to sacrifice quality because I did not want to lose my ability to function due to loss of sleep and I did not want to sacrifice other projects.”

“During the first year of my internship, I would occasionally make compromises in laboratory data collection in order to meet time expectations.”

Responses such these are representative of the other 16 responses which cite the lack of time or pressure of time. Apathy was the factor for the other 3 responses. These responses would lead

one to believe time pressure in engineering is a major factor in the work done and the quality of the work.

Question 10's purpose was to address the factor of groupthink in regards of not voicing one's opinion in a group setting to avoid conflict. Of the 22 that were given this question, 16 of the participants have been in a situation where group think played a role. Groupthink in engineering is dangerous because without the diversity of ideas, designs that are not optimal may go through that will put people at risk.

“When the senior man in charge is wrong, you begin to first give your helpful input as to why you believe this route will fail. When he decides he's going to show you a thing or two and belittle you for questioning him, you sit back and smile to say “I tried”. Then you allow him to create a failure (assuming no safety issue is present). The classy part is to then not hold this against him and move forward. They will not forget you were right, and they will definitely not forget you allowed them the curtesy of recovering from a failure in peace. And just like that a bad situation born of authority is a bridge to better rapport.”

“This can happen often in multi-disciplinary (or cross function/CFT) teams. You can often be in a position where another member is saying something that is not technically accurate and you can hesitate to refute them in order to avoid conflict in person. I had this recently when it came to an engineer working in another department had called out a practice that he had seen in a previous project that was not good practice. The engineer requested that we, as the site owners, simply step in and give orders to a contractor that was a sub-contractor of our on General Contractor on site. This poses a liability risk since

as soon as they take direct orders from us (and not the GC), we become liable for the entire site as well. Should an injury occur, both us and the GC would be fully on the hook for compensation. Rather than refute him in an already heated argument, I decided to write an email with the liability codes and guidelines from provincial legislation.”

In the first response, there is seemingly a culture of groupthink in this situation where speaking out would lead to the belittlement of the person. In this case, groupthink would be reinforced by obedience to authority due to the fact they don't want to voice their own opinions in an attempt to not be chastised by their authority figure. In the second response, loss aversion played a role in the factor of groupthink because they didn't want to voice their opinions on the matter because that would make them liable for the site. In this regard, it can be seen that there are many factors that can cause groupthink to occur such as loss aversion or obedience to authority.

In conclusion, engineering, just as other fields, has its own ethical culture that engineers have to contend with everyday. From the survey, it would seem time pressure, loss aversion, obedience to authority, and groupthink are four factors that exist as a constant struggle that influence the ethical decisions that engineers have to make. Obedience to authority in particular seemed to have been a running theme throughout most of the answers in this survey, so one could assume the culture of engineering may be the root cause of why this may be the case. As engineers, the effort must be made to be ever vigilant of the factor that may influence ethical decisions and take into account when making said decisions. In the next section, a case study on the Florida International University Bridge collapse will give an example of the dangers of seemingly mundane unethical decisions that can lead to ruin in engineering.

Case Study: FIU Bridge Collapse

Introduction

Figure 3: Picture of the collapsed FIU bridge

On March 15th of 2018, a pedestrian bridge being constructed for Florida International University collapsed killing 6 people and injuring 8. At the time of the incident, the road had not been closed, so among the casualties were citizens commuting to work and school. The site of the bridge collapse can be seen in figure 3. The bridge was designed by FIGG Bridge Engineers who received most of the blame from Occupational Safety and Health Administration (OSHA) for the collapse [USToday]. The other contributors to the collapse were Florida International University, Munilla Construction Management, and the Florida Department of Transportation

which one could make the argument was also responsible [insert evidence] have just as much to blame for the collapse as FIGG due to poor oversight.

Key Participants:

FIGG Bridge Engineers (FIGG) (Engineer on record EOR)

Denny Pate (Engineer at FIGG)

Dwight Dempsey (PE of FIGG)

Munilla Construction Management (MCM) (contractor)

Rodrigo Isaza (Senior Project Manager)

Ernesto Hernandez

Pedro Cortes

Structural Technologies /VSL, LLC (Post-tensioning)

Kevin Hanson (Supervisor)

Navarro Brown

Chester Ashley

The Louis Berger Group, Inc. (peer-reviewing)

Florida Department of Transportation (FDOT)

Florida International University (FIU) (owner)

Chronology of Events

Figure 4: Diagram of the design of the bridge (US Today)

The pedestrian bridge was designed to be an innovative single concrete truss bridge with cable support as shown in figure 4. FIU prided it for the implementation of the Accelerated Bridge Construction method of rapid development. ABC is bridge construction that uses

innovative planning and construction methods in a safe but cost-effective manner to reduce construction time. A common reason to use ABC is to reduce traffic stoppage to account for safety of the traveling public and to reduce economic impacts. FIU initially claimed the bridge would last for a century and be able to withstand a category 5 hurricane.

Figure 5: Diagram of the plan to construct the bridge (OSHA)

However, in an investigation done by OSHA, the bridge was found to have a number of structural design flaws that contributed to the collapse. (Osha) Louis Berger was the company in charge of peer-reviewing the bridge design, but they had not had the chance to peer review stage 3 of the bridge as shown in figure 5. The bridge had only been in place for five days before collapsing and within the first two days cracks could be seen in the bridge. When the first cracks appeared, a loud noise rang out throughout the air which frightened Munilla Construction workers and pedestrians alike causing them to flee.

6:

Figure 6: Picture of cracks (OSHA)

Figure 7: Another picture of cracks (OSHA)

Three VSL employees, Navarro Brown, Chester Ashley, and Kevin Hanson noticed the cracks that had formed as shown in figures 6 and 7, documented them, and sent them to Sam Nunez, his supervisor, to report the potentially dangerous implications these cracks had. He then spoke to Pedro Cortes. Pedro Cortes and Ernesto Hernandez examined the cracks and sent photos to Rodrigo Isaza who sent an email concerning the crack to Dwight Dempsey at FIGG. In the email, Rodrigo Isaza had said, “some of these cracks are rather large and/or of concern.” Dwight Dempsey copied FIGG engineers including Denny Pate. FIGG assured them that the cracks were within a reasonable margin based on the pictures sent. Despite this, it would be later determined in a report released by OSHA [OSHA] that if FIGG had been more proactive such as having the bridge more thoroughly peer-reviewed by Louis-Berger or asking for more information on how the bridge was cast then they might not have missed a key factor that would have made the cracks too dangerous to ignore. FIGG instructed MCM to re-tension the bridge which is extremely dangerous with the cracks present, but due to the assurance of safety given by FIGG, MCM proceeded with the re-tensioning despite VSL employee Kevin Hanson warning about the cracks. [OSHA]

Denny Pate went to inspect the bridge the morning of the collapse to discover that the cracks looked much worse than in the pictures. Despite this in a meeting on the day before the collapse, FIGG officials gathered everyone involved in the bridge collapse to reassure workers that the cracks were minor and not a problem, and because the loading of the bridge was temporary (the main structure was still being made by MCM), it would hold until the structure was done. Despite FIGG not knowing why the cracks were forming, they insisted it was minor and safe. However, FIGG did know that the cracks were on a part of the bridge that was

nonredundant and a failure in this location would cause the bridge to collapse. Louis Berger Corp had not yet had the chance to peer review that part of the bridge, but when asked by FIU, they told them that the analysis had fully been peer-reviewed..

Relevant Ethical Principles from Engineering Code of Ethics:

Engineers shall hold paramount the safety, health and welfare of the public and shall strive to comply with the principles of sustainable development in the performance of their professional duties.

a. Engineers shall recognize that the lives, safety, health and welfare of the general public are dependent upon engineering judgments, decisions and practices incorporated into structures, machines, products, processes and devices.

d. Engineers who have knowledge or reason to believe that another person or firm may be in violation of any of the provisions of Canon 1 shall present such information to the proper authority in writing and shall cooperate with the proper authority in furnishing such further information or assistance as may be required.

Case Study Questions

1. What behavioral factors may have played a role in this case study?
2. What were the main unethical decisions made throughout this process?
3. What ethical codes were infringed upon in this case study?

4. From the evidence provided, what entity or entities seemed to be at fault for the bridge collapse, and what decisions could they have done to prevent the collapse?

Behavioral Factors that Played a Role in the Case Study

In this case study, there were certain factors that affected the choices of the individuals in the bridge collapse situation. It was determined by OSHA that the bridge collapse was caused by the following reasons.

- FIGG failing to recognize that the bridge was in danger of collapsing when it was inspected hours before it had collapsed.
- The bridge, which had been designed by FIGG, had structural deficiencies that contributed to the collapse during stage three. FIGG should have allowed for proper peer-reviewing by the Louis-Berger group.
- MCM was being aware of the growing cracks as reported by the quality control personnel and superintendent should have sooner notified FIGG above the growing cracks, and FIGG should have more quickly acted on the photographs and measurements of cracks provided to them by MCM.
- MCM should have used their own professional judgement regarding the situation as the constructor of the bridge to close down SW 8th Street until the cracks were found by FIGG to be harmless. However, they deferred to the decision of FIGG.

From the information stated above, FIGG engineers had two main behavioral factors that affected their decisions in this situation. The overconfidence bias affected them due to the fact they assumed that they were acting in the right because they expected the main support to be

constructed before anything happened which leads to the other major factor that affected FIGG.

Ethical Framing was the main issue FIGG dealt with due to the fact they did not fully understand how dire the situation was when they acted.

MCM showcased another major role in the bridge collapse because they were the closest to the situation, but they took the word of FIGG despite the fact FIGG was the furthest. This was a clear example of obedience to authority because instead of relying on their own opinions they only took the opinions of FIGG. Groupthink also played a role because everyone listened to what FIGG said despite they were all professionals in the field.

To wrap up the case study it would be nice to have (1) a few general questions about behavioral factors and an external document or two (perhaps one from the citation list) that students can read to answer the questions, and (2) your evaluation of potential behavioral factors that may have contributed, and any evidence you have to support it.—————

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