

TEACHING OF BIOMEDICAL ETHICS TO ENGINEERING STUDENTS THROUGH THE  
USE OF ROLE PLAYING

Interactive Qualifying Project Report completed in partial fulfillment of the Bachelor of Science  
degree at  
WORCESTER POLYTECHNIC INSTITUTE

by

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2017

Submitted to

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## **ABSTRACT**

Many students upon graduation are unprepared to deal with ethical issues presented in their careers. This is despite engineering curricula requiring that students learn about ethics and that the teaching of ethics must be incorporated into a degree program in order to receive accreditation. This is often difficult to incorporate in engineering programs due to the large amount of subject matter and tight time constraints these programs often have. Institutions have attempted to find several different ways of adding ethics into their engineering requirement without making it a required course. Previous projects that have been performed by teams on Worcester Polytechnic Institute's campus consisted of a variety of methods, such as a joint-venture approach, guest lecturers, and videos, that were brought into engineering courses. The problem with these methods was that the engineering students were often unable to fully see the connection between ethics and engineering and its importance to their major. The goal of this project was to create an engineering ethics module that, if performed in an engineering course, would allow students to see the direct connection between ethics and engineering and be more comfortable and able to identify and overcome ethical dilemmas that may arise in an engineering workplace. Students were asked to read a pre-reading on a case study relevant to their major field of study, with information on an assigned ethical theory and what stand it would take on the case before the in class activity. Then in the class, the students would roleplay as an ethical theory and try to rank a series of variables on the scenario in a variety of different group compositions. Finally, the students were asked to answer a set of survey questions, which were able to show that this approach was able to successfully enable students to see the direct connection between engineering and ethics.

## **ACKNOWLEDGEMENTS**

The IQP team would like to take a moment and thank our advisors Professors Geoffrey Pfeifer and Kristen Billiar for all of their support and guidance throughout this project. They were an integral part in ensuring our team was a success. The team would also like to thank Professors Craig Putnam, Ken Stafford, Dirk Albrecht, Jahangir Rahman, and Sakthikumar Ambady for allowing us time in their classes to perform our ethics activities. Finally, our team would like to thank all of the students who participated in our activity and gave us feedback.

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## **EXECUTIVE SUMMARY**

**Introduction:** The Teaching of ethics to engineering students is of the utmost importance and can be overlooked at times. Engineers today need to be able to make ethical decisions on their own and Engineering Institutions have to provide them with the knowledge to handle ethical situations. The key problem is that many engineers fail to see the direct connection between ethics and engineering, thus causing them to become disinterested in the ethics education. The key focus of this project was to create something that allowed students to view ethics as an important part of their curriculum and actively engage them. We hoped to accomplish this by introducing ethical theories in a type of role playing module, that would bridge the gap between ethics and engineering for students.

**Background:** Engineering is accredited by ABET and to get that accreditation teaching institutions need to meet certain ethical education standards set by ABET. Most places hiring engineers would look for this accreditation so it is important that the standards are met. Previous IQP's worked on meeting these standards by having guest lecturers, videos and in class discussions based on case studies. While these were moderately successful, based on the responses we saw, we thought they still did not quite make the connection between ethics and engineering. We looked into active teaching methods and the advantages they offered, like increased participation. We also researched more into some of the difficulties in teaching ethics and the disconnect many engineering students faced when discussing ethics. We researched effective and fun ways of teaching and what we had to do to properly teach students ethics. We primarily looked into roleplaying and case studies for the purpose of our activity as they are active teaching methods that have proven effective at engaging students.

**Methodology:** Two different implementations were created to implement in different engineering courses. The first was a roleplay that focused on a specific case study for the class. These roles were job positions that the students may be familiar with. They were then asked to prioritize design properties of a device and asked to do so from an ethical standpoint with a group of other people in the same role. Afterwards the groups were reorganized in a way that only one member of each role was in a group. They were again asked to prioritize design properties. During each stage the students wrote down their prioritization based on group conversation, which could be used to measure change in opinion while also keeping the students engaged. Last they were shown a case study of the device failing due to the lack of prioritizing a design aspect, and then were again asked to prioritize from personal opinion. They then filled out a few survey questions which were used to measure engagement, educational outcomes, and confidence. Our second role play was very similar except the roles were changed so that students would roleplay as a certain ethical theory and argue from that standpoint. The case study was also altered to not focus as much on design properties but to focus on the impact the product has after it's been created.

**Results:** The post surveys were able to show that the first activity did not yield the desired success as the students only answered the survey questions positively just over half of the time on average. The second method's surveys yielded much more positive results showing that the method was a much better approach that could accomplish what the team set out to achieve. The percentage of students who were answering neither yes nor no drastically increased from each activity to the next.

**Discussion:** The first implementation of the ethics activity failed to get the majority of students to see the direct connection between ethics and engineering, but it was able to generate desired

discussion during the class. This helped build the framework for our next implementation. The second implementation worked to counter the problems of the first and successfully was shown to solve many of the initial problems encountered, like lack of connection to ethics while generating the types of positive results the team desired from the students, such as better discussion and more questions during discussion. When the second method was expanded into robotics courses the amount of student uncertainty increased significantly, as seen in figure four, despite the net positivity remaining relatively the same from lesson to lesson, which is shown in figure five. The team developed a few theories as to why this occurred consisting of time constraints and an increase in the activity's ability to challenge the students pre-held notions on ethics. Another large factor was behind the strength of the case study to produce good ethical issues separated from pulley design problem.

**Future Recommendations:** The developed method for the second implementation was shown to be an effective ethics education lesson structure for introducing ethics to engineering students, but still has several improvements that could be made to it. The largest of these improvements would be making the activity easier to develop without causing it to be less effective. This would make it much better for professors who would like to use the method in their classes, but are unsure how to fully create a lesson using the method specifically for their subject fields. Teams in the future could also work to try to determine the if the lesson has a long term impact on the students or if the activity receives the same results if the follow up survey is not done immediately after the lesson. Finally, future research could be done in determining if there is a more ideal set of ethical theories that could be used for this lesson or if there is a more ideal way to gather and interpret data obtained from the students.

**Conclusion:** Engineering students are not receiving the degree of ethics education that is needed in order to identify and overcome ethical dilemmas in the professional workplace. Even with an ethics education students often are unable to see the direct connection between ethics and engineering. An interactive and adaptable model was developed in order to bridge this knowledge gap. The method developed uses role playing with case studies in order amend the gap with real life situations and theories in order to help students see the connection between ethics and an individual student's major field of study. The data collected throughout this IQP demonstrated that the developed ethics lesson structure was an effective method of introducing ethics to engineering students, and helping students consider problems in different points of views.

## **I. INTRODUCTION**

Ethics is a vital part of any upcoming engineer's education. Just as math, science, and engineering classes provide vital tools necessary for any student seeking to be an engineer. Ethics also provides essential tools that are indispensable for a professional engineer's identity [1]. Ethical education has been deemed of such importance for engineering majors that large organizations, primarily the Accreditation board for Engineering and Technology, or ABET, have been requiring a certain amount of ethical education for students who intend to graduate with a degree in engineering [2]. Ethics is so important that one of ABET's specific requirements an engineering program to receive accreditation in 2015-2016 is that an institution must teach its students how to be ethically and professionally responsible [3]. One of the reasons that ethics is viewed as something important to an engineer's educational experience is due to fact that it provides the necessary tools that they will need to use when ethical issues arise in their professional career. Having an engineering ethics education will also help engineering students become more aware of and better suited to deal with real world ethical scenarios that may arise throughout their careers [4].

When studying engineering ethics we observe that there exist a problematic gap around the instated institutional criteria. When looking at the specific ethics course criteria for certification, ABET is quite vague in addressing how universities are supposed to include ethical education into their curriculum [2]. This puts the majority of the responsibility on the institutions themselves to develop a way to properly create and incorporate some sort of engineering ethics course requirement to meet all accreditation requirements. This vagueness makes it far more difficult for a university to decide the best method to use when addressing teaching ethics. Multiple institutions across the nation are meeting this requirement in a variety

of different ways, there is no way to be able measure which is the correct or incorrect method that should be used in achieving the the desired ethics educational outcome which ABET wished to achieve when they created this vague criteria.

Worcester Polytechnic Institute is accredited in all of its major engineering degrees by ABET criteria requirements, despite their not being a formal structured format for taking an ethics course prior to graduation [5]. WPI, like multiple other institutions is meeting the ethical education requirements in a variety of ways. One way that WPI is fulfilling the ethical requirement is by offering ethical courses that students can take to fulfill either liberal arts or free electives course requirements while at the same time fulfilling the institution's ethical accreditation requirement. The second way is that throughout their experience at WPI, certain engineering classes and professors may include an ethics lecture for 1 or 2 days out of the term. This secondary way allows the institution to still be fulfilling their ethics criteria requirement while not forcing students to take a full course in ethics. The problem with this at the moment is that there are really no guidelines or measures in place currently at the university to ensure that students are receiving the level of ethics education that they are expected to be receiving [3]. This unstructured approach may leave students unprepared when entering the work environment and when they are presented with these ethical dilemmas, which they may not have experience dealing with [6].

These different institutional challenges, could potentially lead to graduating students being unprepared to deal with ethical dilemmas in a professional setting. One of the problems in addressing modern engineering students is that many seem to believe that they ultimately just create technology and are not truly responsible for how it gets used or they do not see a connection to ethics for the most part [7]. The separation between engineering courses and

engineering ethics may lead to further alienation of ethics as not central to engineering [7].

The challenge when addressing this specific knowledge gap problem is how to truly teach a student ethics in a way where they can clearly see a connection while also holding their interest. We have to start by considering the institutional challenges that every engineering program runs into. Many different universities and professors are attempting to find a way to give students the tools necessary for their engineering careers in ethics classes [8]. By institutional challenges, we are referring to the question of how to incorporate ethics into the curriculum in an effective way that will benefit the students. We also need to consider the instructional challenges that are also very important when thinking about how to best make sure that we are bringing this gap for the students in a way that is very comprehensible. When we consider some of the instructional challenges we have to look at what would be the best teaching method for the students to best understand the material and see the connection.

We looked at multiple different teaching methods and the differences between passive and active teaching. What we learned is that a great method to use to increase interest was an active teaching method. Active teaching methods are more concerned in giving students the skills in which they acquire knowledge through active participation in the lesson [9]. We found that the use of case studies were a great tool to use to convey messages to the students in a easy way for them make connections and understand concepts. We also found that even though the instructional challenges were addressed by the previous IQP in a variety of ways, students usually failed to see how ethical education or more specifically ethical theories connected with their studies [10]. This a common problem with the traditional approach of teaching ethical theories to engineering students.

This project is focused on creating an interactive teaching module that will help students see the direct connection between ethics and engineering. The module will be an interactive roleplay that will use a case study to bring up ethical dilemmas, while using ethical theories as playable roles in which to view the dilemmas. The team's theory is that by making this connection more clear we will significantly increase the individual engineering student's ability to understand and address everyday ethical conundrums that they may encounter. An ethics role playing activity within engineering classes with real life problems helps students to understand that ethics is a part of their education and professional identity. They can connect it directly to their studies and decisions, and the decisions of their peers, on a personal level. This method also encourages good discussion and the ability to look at a situation in a variety of ways. This project will implement a series of fully developed roleplay modules into different engineering courses to assess which ethics lesson method enables students to make these concrete connections and if, with this knowledge, the students feel better prepared to deal with ethical dilemmas they may face in the workplace.

## **II. LITERATURE REVIEW/BACKGROUND**

### **2.1 The Need and Importance of Teaching Ethics**

Ethics is a vital part of any upcoming engineer's education. The Washington Accord which is an international agreement between different bodies responsible for accrediting



engineering degree programs considers the teaching of ethics to undergraduate engineering students as an essential component of the engineering curriculum [11]. Just as math, science, and technology are key parts of an engineer's education, ethics also plays a major role in the formation of individual students' professional identities. Engineering ethics courses usually have the intention of teaching ethical responsibility to the engineer [12]. The first purpose of teaching ethics in engineering schools is to make sure students understand that ethical issues are an integral portion of being an engineer [13]. Having an engineering ethics education will also help engineering students become more aware of and better suited to deal with real world ethical scenarios that may arise throughout their careers [4]. Taking a course on engineering ethics enables students to possess a greater confidence in their moral reasoning skills, and develop a more sophisticated understanding of professional responsibility. This includes their personal awareness of social consequences that may result from their decisions [1].

Ethics is such an important topic that organizations, such as the Accreditation board for Engineering and Technology (ABET) and the Royal Academy of Engineering (RAE), highlight and require that students receive a certain amount of ethics education throughout their engineering degree program in order for the program to receive accreditation [3]. This is all set in place to ensure that students are meeting the proper educational requirements that are needed in order for the students to become professional engineers. All major engineering programs within United States strive to meet the ABET accreditation requirements in order to guarantee that their graduating students are meeting the desired standards for their degrees. ABET inspects the programs and certifies that the graduates of the programs are meeting certain standard requirements in terms of course types, content coverage, and demonstration of competence [4]. Accreditation is extremely important because it guarantees to employers that the graduates of the

accredited university meet certain professional standards that are desired for any given job. Whether an engineer had graduated from an accredited university or not is especially important due to the fact that engineers are capable of practicing with or without an engineering license. An accredited engineer therefore is better trained to deal with ethical scenarios presented in the workplace, which can look very positive when applying for a job. However a non-licensed or non-accredited engineer is less likely to have had many of these ethical dilemmas and may not handle ethical problems as well as someone who has experience or background knowledge of ethics.

When it comes to the ethical standards expected of an engineer in the work force, practically every company possesses a code of ethics by which employees of the company must agree to and are expected to adhere to when ethical dilemmas within the company are encountered. These codes of ethics themselves, however, fall flat as ethics in engineering can need more than the ethical theory is able to provide as ethics is more than simply making a good decision when a choice presents itself [4]. Professional codes of ethics are a good starting point for recognizing the current standards and expectations of practice in any given company, but ultimately the codes are only a series of guidelines and cannot be used to deal with every possible situation that could arise [14].

## **2.2 What Previous IQP's achieved**

The Previous Interactive Qualifying Projects, IQP's, focused on the topic of increasing ethics education for engineering students. They have achieved a satisfactory level of success in encouraging people to consider their own values and to attempt to navigate through any given ethical situation. In 2014, the IQP primarily focused on a single case study in which students

were assigned a variety of questions related to an article on the case study. The questions were used to determine the students' views and opinions on the case study and once the questions were completed a class discussion was held as a follow up on the topic. Once the discussion had been completed, the students were asked to review what they said in their original arguments and provide counter arguments to their own original arguments now that they had heard the views held by their peers. The argument/counter argument proved to be an ineffective method of changing people's perspectives on the topic of ethics as 80% of respondents had an unchanged viewpoint [15]. The alternate assignment featuring the case study, however, proved to be much more beneficial as 79% of students said they would use it again. These figures prove that the case study method was a much more effective measure in generating ethical interests [15].

The 2015 IQP used a joint venture approach based on the idea that not all the professors had a deep understanding of ethics and were not all comfortable in teaching ethics to students. This approach involved a point-counterpoint based argument on ethics. A case study with questions was presented and then followed up presentation given by a philosophy professor. After collecting their survey results, they were able to determine the differences in participation and impact on students across different grade levels. Based on the results of the study, roughly 57% of the students preferred the ethics professor's follow up presentation over the case study method of teaching ethics. After all of the in class modules were conducted, the follow up survey revealed that over 80% of the students that participated felt that they could better identify, analyze, and handle ethical situations experienced in the workplace [10]. This statistic is quite promising as it shows the promising results of the introduction of ethics education directly into engineering courses [10].

The 2016 project used a blended approach that incorporated many different methods such as, videos teaching ethics, a case study, and an ethical discussion to promote a larger understanding. This group study was able to survey roughly a tenth of the engineering undergraduates, thus giving them a large array of data on the implementation of their project. The goal of their project was to get rid of the long class discussions from the prior IQPs in favor of a more scalable approach by using an online ethics module that was followed by an in-class group discussion. The results of their lesson can be fairly clearly interpreted as many of the students were exposed to ethical concepts without having taken a stand alone course on ethics. When asked about the statements, 57.28% of the responses by the students agreed with the given statements, while a lower portion of the participants disagreed [16]. After the students were given a case study, the blended and joint venture approach was put to test. The results were then statistically analyzed through six questions. In conclusion, the blended approach was ultimately preferred by the study for use in teaching ethics [16].

The common trend found throughout these previous IQP's is that they presented an ethical dilemma that was then looked at from various viewpoints in order for students to understand ethics. This included addressing the multitude of different decisions possible and the arguments for each of the possible choices. While these IQP's were fairly successful, in one way or another, at addressing the institutional and instructional challenges of teaching ethics, holes still existed. Thus, our plan is to fill the holes from the prior IQPs is to create an interactive role playing game. The main problem we saw in the previous IQP's was that they failed to engage students and get them to talk. Getting students to actively engage with one another and facilitating discussion between students will help students gain a better understanding and appreciation of ethics. We decided to look into more active methods of teaching for our project.

We believe that this will result in a much greater impact on engineering students, thus proving that facilitating discussion among students and getting them more engaged is a more effective way to teach ethics.

### **2.3 The Difficulties and Obstacles of Teaching Engineering Ethics**

Since the 19th century, academic programs have replaced the use of apprenticeships in educating professionals and now bear the primary responsibility for preparing students to become engineers [1]. Implementing ethics as an essential part of an engineering education has raised the problem that there is no standard across the board that has been set to be able to teach or incorporate ethics into the student's education [2]. Everyday schools and professors are attempting to figure out what is the best approach to make sure that students get the information they need out of the class, while meeting the ABET requirements [8]. Schools of Engineering and technology are examining ways to compress the assessment burden and create one instrument that will satisfy numerous accrediting body standards of ethics [17]. In a sense due to the multiple requirements that are expected to be fulfilled from ABET Institutions are working on a way to be able to in a sense consolidate all the requirements in a way that within one course or one part of the accreditation you can satisfy multiple requirements. The question of who should be teaching these ethics courses is also a topic of concern. Should an engineering professor teach the student's or should classes bring in a philosophy professor specifically for ethical lessons? There are both pro's and cons of having either an engineering professor or a philosophy professor teach engineering ethics classes. It has been argued that ethics should be taught by an engineering professor as a way of showing students that ethics is central to engineering and not a peripheral to it, as students may assume if all ethical lessons are taught by

philosophy faculty [13]. However, a philosophy professor may be better suited and more comfortable teaching ethics and giving students the information they need, but there might be a disconnect with the students as they might not see ethics as an important part of their engineering education. On the other hand an Engineering professor might not feel as comfortable with teaching the subject matter and may not be as well equipped.

The ABET accreditation requirements do state that students must be receiving some level of ethics in their education on engineering topic of engineering ethics to allow them to identify and address professional ethics, but it never states how these requirements actually must be met [3]. This allows for universities such as, Worcester Polytechnic University, to have accreditation in their engineering programs without any proper structure in place for ethics educational requirement [5]. This makes ethics a difficult topic to teach to students as professors are expected to incorporate the material into their lectures without any specific guidelines being set for how or when they are to be properly implemented. It also becomes difficult for the topic to be fully covered as individual professors may expect the topic to be covered more by other courses, so they don't need to go too deep into ethics. Since the rules on how to provide students with enough proper ethics education are so vague, it makes it harder on universities to justify mandatory ethics courses or to ensure ethics education is taking place as much as it should in engineering courses.

## **2.4 Teaching methods**

### **2.4.1 Three criterias to successfully teach ethics**

In order to educate students on the topic of engineering ethics, three major areas need to be covered. First students need to find emotional fulfillment throughout their ethics edification

[18]. A fruitful ethical education should encourage students to care about ethics, to care about navigating ethical dilemmas, and to be ethically and professionally responsible [18]. Motivating students is the most critical task that must be achieved in order to maximize the impact the method has on the students. Secondly, the lesson should develop the student's intellectual abilities in handling ethical dilemmas. In the working force, students will have to face decisions that could be quite challenging to overcome. The implemented teaching method should offer a helping hand to guide students through these ethical impasses. This second component could be adequately covered using active teaching methods, such as case studies and role play [18]. The third component of an impactful ethical education is theoretical knowledge. An education in ethics must give students an overview of all of the generally accepted ways of defining what is right or wrong [18]. Monzon argues that, when it comes to BME students, in order for them to be completely ethically educated, they need to have an in depth knowledge into the fields of bioethics, research ethics, professional ethics, and social ethics [13]. There is a debate as to how much theoretical knowledge, such as philosophical moral theories, should be taught to engineering students [8]. On the other hand, it can be argued that theoretical knowledge could be a useful tools to broaden the student's' perspective regarding ethical decisions.

#### **2.4.2 Passive and active teaching methods**

Teaching methods are an essential part of the edification of students within the classroom and have been studied for as long as classrooms have been around. They are tools by which teaching is facilitated and this makes it both important and difficult for teachers to determine the best method to teach [9]. In choosing a teaching method, the question is how to best teach a

student ethics so that the students will be most capable of identifying and overcoming ethical dilemmas they may encounter in the future [19].

Teachings methods generally fall into two categories: active and passive. Active teaching methods are more concerned in giving students the skills in which they acquire knowledge through active participation in the lesson [9]. Examples of active teaching methods are role playing, debates, case studies, games and simulation. There are also more traditional active teaching methods such as small and large group discussions, group projects, and exams [19]. These are active teaching methods because they challenge the mental faculty of students and capture their interest [20]. Passive teaching methods, on the other hand, are teaching methods that do not involve the student in the learning process in any significant way [20]. A very basic example of a passive teaching method is a teacher lecturing a class while students are simply taking notes. This is a passive teaching method because information is directly stated and processed by the teacher to the student without them actually participating in the processing of the information or the lesson itself at all [9]. Here, the only involvement the students have with their education is for them to memorize information [9]. Alternatively, in active learning, students are more involved in their learning process than just listening to the teacher as they are actually participating in the teaching method [20]. Many active learning methods often require the students to prepare for the activity before the class, therefore minimizing group time just passively preparing and maximizing the time that can be aloted to active learning. There is the expectation that students have developed the ability to passively learn through literature and other sources already, so it becomes more important to maximize the learning potential in a class setting by prioritizing using this time on active learning methods for the most part.



### **2.4.3 Advantages of active teaching methods**

There are several advantages to using active teaching methods in the classroom setting in order to teach students about any given subject. Active teaching methods, in part, have achieved great results due to how it places students at the center of the lesson [9]. This makes active learning an especially effective method due to how it emulates the real world in which the student will be ultimately responsible to decide upon ethical issues or dilemmas. Active teaching methods also give students the ability to decide on the course of their learning process, their level of involvement, and their ultimate learning outcome [20]. Active teachings methods are also much better at generating student interest than passive teaching methods, which should increase students' motivation to learn [9]. Additionally, active learning tends to also increase student participation in the teaching of the subject itself and has been shown to increase student participation in following classes even after the activity has ended [21].

### **2.4.4 Case Studies**

There are many active teaching methods that can be used to develop a student's understanding of ethics. The most prevalent and dominant one is the use of case studies [6] [22]. They are considered active learning methods because the mental faculty of students are challenged. Students are forced to analyze and deal with ethical dilemmas that come up within a certain situation. Case studies give students a realistic situation that involves ethical consideration that is related to their major. Typically, students will be required to read a case study the day before the class then come to class prepared to discuss the case study in small groups [23].

There are four main types of cases: history, problem, study, and multimedia. A history case will present the students with an actual event that occurred in the past, usually one that had resulted in disaster or failure [23]. In this activity students will take the event, analyze its different components, see how the disaster was handled, and identify what they have learned from it [23]. A problem case provides students with an ethical dilemma with no apparent solution. Students have a total freedom in identifying and choosing their solutions [23]. A case study is similar to a problem case in that they both include an ambiguous situation while leaving finding the solution to students. The only difference is that some case studies include an ideal solution or result, while case problems do not [23]. This is why case studies are such a powerful tool in teaching students about what appropriate actions to take in a certain situation. The next type of case, a multimedia case, is a case that uses technologies, such as computer graphics or videos, to better the experience of students. This is especially important when providing cases to engineering students which has numbers and graphs and figures [23].

It is really important to choose the correct case in order to maximize the learning potential of the students. There are some guidelines in choosing the correct case for a particular class or lesson. First, the problems or the events should be relevant to the students [23]. The problems that come up in the case should be similar to the problems that they are going to solve in their future careers in order to maximize personal interest and involvement. A case study about stress failure is not relevant to a BME student, for example. Second, the case should have a certain amount of complexity that will motivate students to think critically [23]. Third, the case should enable the students to bring and identify the various dimensions of an event or a problem [23]. Some students only see the technological implications of their actions, but they also should take into account the ethical, social, political, and business consequences of their

work. Finally, the skills and knowledge learned from a case should be transferable to other cases [23].

#### **2.4.5 Codes of Ethics**

Another method of teaching ethics is through codes of ethics, of which there are thousands of examples [24]. Almost every profession has a code of ethics in one form or another. Codes of ethics are documents that describe the ethical responsibility of those in that profession [13]. It also summarizes the problems for those in the profession [13]. They also tend to provide guidelines and ways to better identify problems, as well as the professional standards for the job [24]. Moreover, codes of ethics tend to have a utilitarian perspective in which the well-being of others is accounted for primarily [24]. However, they tend to lack any details on how to handle specific individual ethical situations [24] [19].

There are two types of codes of ethics: aspirational and operational. Aspirational codes of ethics have an idealistic vision of what an ethically responsible professionals should be like [24]. An example of what an aspirational code of ethics could look like is the BME code of ethics. In the BME code of ethics you have statements such as “Protect the environment” and “promote social justice” [13]. This is an aspirational code of ethics because it lacks any guidelines or sanctions in case of a violation of the guidelines [24].

On the the other hand, operational codes of ethics focus more on providing behavioral guidelines that is consistent with the code of ethics [24]. This allows companies and governmental entities to possess a way of punishing any violation of the code, such reprimanding, dismissal from the job, or criminal prosecution which will greatly enhance the operational aspects of the code [24]. An example of an operational code of ethics is the code of

ethics for the Government service. It has statements such as “Never discriminate unfairly by the dispensing of special favors or privileges to anyone” and “Expose corruption wherever discovered” [24]. These statements are not idealistic goals, but rather they are concrete behavioural guidelines.

There are problems with using codes of ethics as a tool for teaching ethical responsibility. In the engineering profession, codes of ethics are rarely referred to unlike in other professions such as law [6]. Codes of ethics also should be taken as an aspirational tool when used to handle ethical dilemmas. This is because often times the code does not specify how to act in certain situation [19]. Finally, the reason for creating a code of ethics should be investigated before using it. Some codes of ethics are written more to give legitimacy to a profession or to a company rather than to be a tool for enforcing professional responsibility [25].

#### **2.4.6 Games**

Another active teaching method is games. Games are capable of providing socially competitive entertainment that is guided by rules [22]. There are several approaches that could be used to teach ethics and ethical responsibility through games. An example of one of these such methods is using a Bingo board to teach ethics in which every square on the board contains a code of ethics or an ethical theory. Then, the teacher will present the students with an ethical situation and students need to match the ethical situation with the ethical theory or code of ethics that could apply.

There are a number of benefits to using this type of game, such as the fact that students have been shown to learn more when they are actively engaged in solving problems [26]. Every ethical situation in the ethical Bingo game could fall into more than one category which means

that students will have to think deeply about their choices and defend them. This will increase students' understanding of ethics and their critical thinking abilities. Studies have shown that students have a low capacity for boredom, therefore, a game, which students nowadays are most likely accustomed to, will be interesting to them and will hold their attention more than traditional teaching methods [27]. Moreover, the interest of the students into the subject matter will ultimately increase.

## **2.5 Roleplaying**

Another active teaching method is roleplaying. There are four stages to teaching roleplaying in classrooms. The first stage is called "Notation" [28]. In this stage, the instructor sets up the parameters of what the roleplay exercise is about. This is usually done by handing out a short case study that describes a situation that is relevant to the students' future careers [28]. The selection of the case study is crucial because it sets up the environment for the student and defines the important problems they need to consider. In addition to the case study, students are usually given a script that describes their role that they are going to act out [28].

Professor Wodin-Schwartz uses case studies when teaching ethics in her mechanical engineering course to emphasize what can go wrong when we are not careful [21]. She mentioned that the process of choosing the case study is the most critical part of her exercise [21]. The case study that is paired with the roleplay should be easy to understand and relevant to her lectures, yet they must produce enough controversy to have two equally strong sides.

The second stage of role playing is called "Ensemble" [28]. This is the stage in which the lecturer divides students into groups in preparation for them to act their roles. The acting of roles differs according to which style of roleplaying was chosen by the instructor, and the

limitation of the classroom. There are role playing exercises in which students are moving around acting their roles intellectually and physically. In the other hand, we have role playing exercises in which students are setting and only playing their roles as mental exercises. Also, the instructor has the choice to divide students into multiple teams who are participating in a roleplay at the same time. This approach enables more students to participate in the roleplay and generates more data for the instructor [28]. Or, the exercise can be done by letting only one team roleplay, and other students participate as observers. This approach help students to see how roleplaying work in action. Also, it provides an instantaneous feedback to the students who were involved in the roleplay [28].

The third stage is called “Improvisation” [28]. This when is when the actual roleplaying is happening. In this stage, the instructor should be encouraging student by asking relevant question that will help keep the discussion flowing. A lot of students may reach a quick conclusions and end the roleplay with each other [28]. The instructor should be there to challenge the student to see the full picture and the difficulties in reaching an ethical conclusions. As a part of the roleplay a student may get asked to speak loudly about his or her thoughts. Changing roles between students is also another way extend and enhance the roleplay [28].

The final stage is “Closure” [28]. It is a stage in which the whole class guided by instructor come along to recap the who exercise. It is the most the most important stage in the role play. Students are encouraged to say their opinions about the activity as a whole. These genuine insights and revelations will have an affect on other students. The instructor should, then, give a summary of the activity. This summary should be a mixture of ideas that came in the roleplay with the ethical dilemma at hand. Leaving the summary more open ended will encourage students to pursue ethics further on their own [28].

The effects of role playing in a learning experience can be a far more influential force than simply reciting ethical codes or the teaching of ethical theories in the standard lecture format. In the previous IQP, students were complaining about how they could not see how these ethical theories taught by professors of philosophy connected with their fields of study [10]. Role playing helps to amend the gap between real life and theory [28]. It gives students a context in which they can see these ethical theories demonstrated in real life.

Engineering students have a difficult time seeing ethics in their field. Roleplaying can help students differentiate ethical problems from engineering problems [28]. By implementing real life situations into role playing, students will realize that there are real implications to their decisions.

Using these real scenarios in roleplaying will help students to see the others perspectives [28]. Students may come to class, with their own opinions and perspectives. By experiencing the different roles and listening to different opinions, students will consider the perspectives of others, which creates empathy [28]. The more they are invested in their roles the more it challenges them to reach an ethical conclusion. Role Playing helps create the realization that there are no simple answers.

### **III. METHODOLOGY**

#### **3.1 Restatement of goal**

The goal of this project is to create a role playing module that can help students see the connections between ethical theories and their engineering studies. By seeing these connections, we hope that students will have the ability to understand and be more aware of ethical dilemmas they may have to face in their futures as engineers. This project, should it be successful, will create an effective role playing module that can be implemented into various engineering curriculums that is interesting to the student and will be able to help meet the ABET ethical curriculum requirements for certification of the degree field.

#### **3.2 The Role Playing Module: First Implementation**

The module had two different versions, each of which were tested engineering course. The first is effectively a simple powerpoint presentation with a hand out, as shown in Appendix A. The students are to be given the hand out at the beginning of the class. The handout consists of a series of post survey questions and a table consisting of a number of features and three columns by which the students will be expected to rank the features throughout their discussions. The powerpoint is structured to start off with a short introduction where the presenter explains what the module is and why the class is playing it. The presenter should typically on this slide explain the fact that students are going to have to make decisions on current and relevant ethical decisions in the module and that the questions that students will face may be questions they will have to be able to answer when working as an engineer in at an official company. The presenter



should also try to explain that it is important for engineers in their field to be able to address the types of problems given.

The next slide of the powerpoint will simply explain how the students are to break up into groups and how they are supposed to view themselves as an engineering team consisting of a variety of roles in a real world situation who must all discuss and complete a design based problem. The presentation will have a basic set of rules on how to divide the class into groups quickly and easily, but this is an ultimately irrelevant detail as the presenter can change or edit this as they see fit on the spot. The students are to start off by being divided and put into groups based on role for the first discussion.

Once the setup is complete, the actual module itself will begin with the presentation of the first scenario. The presenter will present the scenario and all of the relevant details about it along with some imagery to help the groups have some sort of visuals to help them fully understand the given scenario. Once the students have been given all of the information they need in order to make an educated decision on the scenario, they will be given the possible features they must rank and then be given time to discuss and come up with what they think is the best decision for the problem. The students are expected at this point to discuss how they would rank the given features, completing the first column of the handout, with their peers of the same role. After the students are given sufficient time to complete their first set of rankings, the presenter should divide the students into new groups consisting of one person of each type of role. Extra students can be placed in any group. In these groups, the students are supposed to argue for their roles point of view with one another to attempt to come up with an agreed way to rank the features, thus completing their second rankings column of the handout.

Finally, a class discussion is held upon each feature in which students are expected to raise their hands based on how they ended up ranking each feature and be able to state their reasonings why. This is where students can see some more of the viewpoints other groups had and the presenter should bring in any other arguments that seemed to have been overlooked. After the class discussion, the presenter should try to explain the importance and severity the discussions actually held in the real scenario. The students should then be asked to fill out the final column of rankings based on their personal opinion and answer any given survey questions individually.

### **3.3 The Role Playing Module: Second Implementation**

The second model was similar to the first except for a few key differences in structuring and some out of class reading. A sheet containing information on a specific case study, related to the topic discussed in class, as well as introductions to five different ethical theories (Social Contract Theory, Kantianism, Social Relativism, Rule Consequentialism, Act Utilitarianism) is provided online to students for reading, as shown in figure eleven. Students should then be divided into five groups, each belonging to one of the ethical theories and be instructed to read the case study and the theory assigned to their group. A few questions can be posted on the sheet to get students thinking before they come into class. At the beginning of class the presenter's should hand out a sheet to be given to each student as they enter class, as shown in figure ten. The students should enter and seat themselves with their group members, once class begins the presenters should start up the powerpoint, and introduce themselves as well as the basic premise of the activity. The next slide should be a quick review of the case study to clarify anything that was missed and catch students who may not have read it up to speed. After this the presenters

should clarify what is on the sheet. On the sheet should be a number of columns with different factors on the left of them. For the case we used these factors were Absence of Available Alternatives, Time to Finish Testing, Adherence to FDA Regulations, Reduction of Risk to Test Subjects, Absence of Local Restriction on Testing, and Minimize Cost of Testing. The next set of slide should take the time to explain in detail how each of these relate to a scenario similar to the case study. The presenters must try to introduce each topic in a neutral way as to not make any individual point seem wholly positive or negative, or attempt to persuade students that there is a “right” choice. After explaining the topics to the students the individual groups should roleplay based on their ethical theory into ranking these topics from the most important to the least important using numerical values. The presenter’s must emphasize that they are role playing from the viewpoint of the ethical theory and not their personal viewpoints on the matter. Groups should be allowed to talk amongst each other and attempt to establish rankings for about five minutes depending on class time. The goal here is to make sure that the ethical theory was taught correctly and to let anyone who did not do the reading have at least some knowledge on what their ethical theory encompasses. Afterwards groups should be split up based on ethical theory and re-structured, so that at least one member from each ethical theory is in the new groups. After this the groups should again rank the factors, while still roleplaying, but also while conversing and attempting to argue for their theory with their group. This is to help show all the ethical theories in a fairly equal light, each student will be explaining the ethical theories to their fellow classmates and the discussion and roleplay can potentially teach students that there are many different opinions and many ways to approach the same problem. Students should be given a bit more time for this discussion than the first, based on class time. After the ranking is done there should be a general class discussion, specifically focusing on how rankings went and

why. The presenters should go through each factor and ask how it was ranked among each group and ask for a defense as for why it was placed there. Students should be encouraged to share their rankings, but as rankings may be kept anonymous, students should not be forced to answer. If no student argues for or against a specific factor, the presenter should make an argument to demonstrate that these are neutral topics with both good and bad consequences. After the class discussion students should be asked to fill out the final column based on their own personal opinions of what they believe is most important. Students should also be asked to fill out the other questions at the bottom, discussing how the activity was received and clarifying on the ethical background of the student. Students should be thanked after completion of the presentation. A single presenter should collect the sheets once students are finished with them.

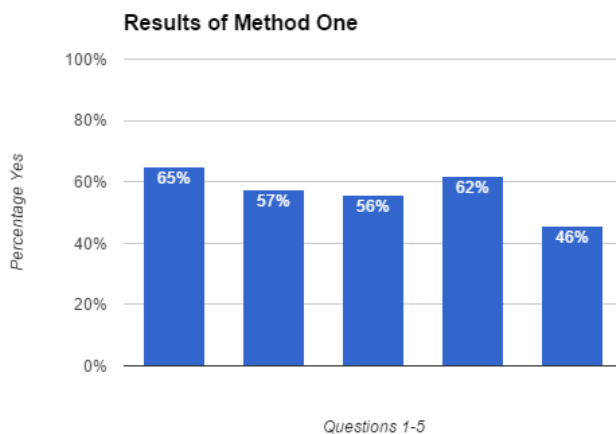
### **3.4 Data Collection**

The end data collection for both of the implementations had the same general structure. Both of the surveys, featured in Appendix A, started with a table with the given factor that students are told to discuss and rank throughout the modules. This data is then used by the team to measure how much the student's opinions changed from one column to another, from which the average value was taken and interpreted. The next portion of the surveys featured a series of questions attempting to measure the level of interest the activity generated in the students, the students' increased comfort in identifying and handling ethical scenarios, the students' views on whether or not they felt roleplaying specifically was a beneficial part of the lesson, and whether or not the students enjoyed the activity. The most important data the group collected was the question asking whether students felt the role play helped them see the connection between engineering and ethics, as seen on figure ten question five. This data was used to see what percentage of students felt that the activity accomplished this task, while the other data was primarily used in order to improve on the activity itself.

#### IV. RESULTS

In total four classes were presented to, two biomedical engineering courses and two robotics course. The first BME course used our first implementation and we collected a total of 68 surveys. Our second BME course and both robotics courses used our second implementation. We collected 35 surveys for the second BME course, 23 surveys for our first RBE course and 43 surveys for our second RBE course.

Figure 1 shows the results from the post-survey of the very first ethics activity the team performed, which was in a biomedical engineering course. This ethics activity was the first implementation in which students roleplayed as a variety of professions working together to develop an electrocardiogram. The following data demonstrate that the activity only yielded positive results from just over half of the students on average. All of the questions related to the overall effectiveness of the activity, from student enjoyment to ethical teaching. The fact that our responses were only just above half meant our activity was not as enjoyable or as effective as we had hoped.



*Figure 1: Results of First Implementation*

1. Do you feel more confident in your ability to understand ethical dilemmas that may arise in the design process?
2. Do you feel that the roleplaying enhanced your understanding of ethics?
3. Would you recommend this activity to a friend?
4. Did you enjoy this activity?
5. Would you consider taking a full (1/3 credit) BME ethics course?

Figure 2 shows the results of the first and second implementations that took place in the biomedical engineering courses compared against each other, displaying only the survey questions that were comparable. This data clearly shows that the second implementation

received much more positive results than the first implementation. The team found that this implementation was much more successful in generating student interest in topic as 83 percent of the students said that they did enjoy the activity. This can obviously be improved upon a bit, but it is still quite the improvement over the last implementation in which only 62 percent enjoyed the activity.

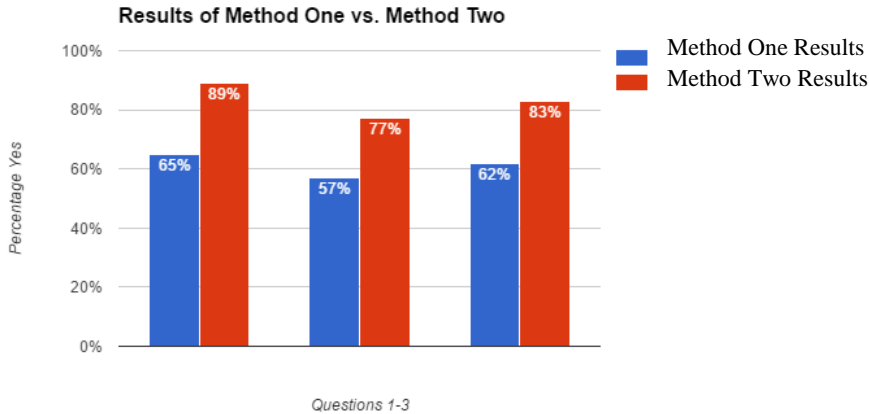


Figure 2: Results of First vs. Second

*Biomedical Engineering Implementations*

1. Do you feel more confident in your ability to handle ethical dilemmas that may arise in your line of work?
2. Do you feel that the roleplaying enhanced your understanding of ethics?
3. Did you enjoy this activity?

Figure 3 shows the comparison between all of the percent yes data from all of the post-surveys from classes in which the team presented lessons using the second implementation method. This data shows that the amount of students answering the questions positively was declining from each activity to the next generally speaking.

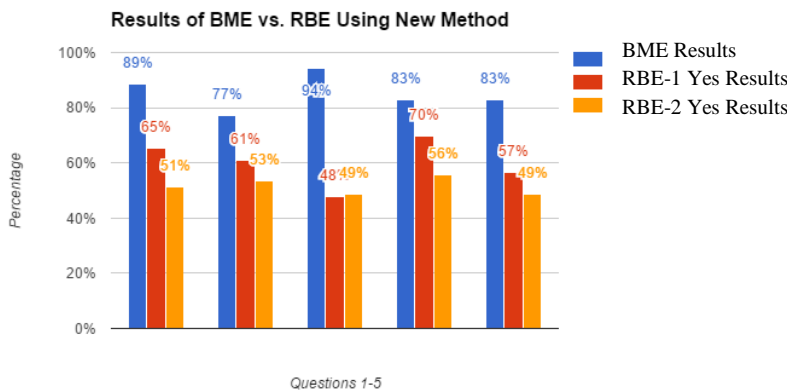


Figure 3: Yes Results of Different Versions of Second Implementation

1. Do you feel more confident in your ability to handle ethical dilemmas that may arise in your line of work?
2. Do you feel that the roleplaying enhanced your understanding of ethics?
3. Do you feel like learning different ethical theories will help you better identify ethical concerns that may arise in the workplace?
4. Did the role play help you see the connection between ethical theories and decisions in engineering?
5. Did you enjoy this activity?

Figure 4 below displays the comparison between all of the percent no and other data from all of the post-surveys from classes in which the team presented lessons using the second implementation method. We graphed this to see if as the yes value went down in robotics, the no value went up or if more students were unsure about their ethical teaching. This data shows that the percentage of students answering the questions negatively was about the same from class to class, but the amount of students that answered other drastically increased each lesson.

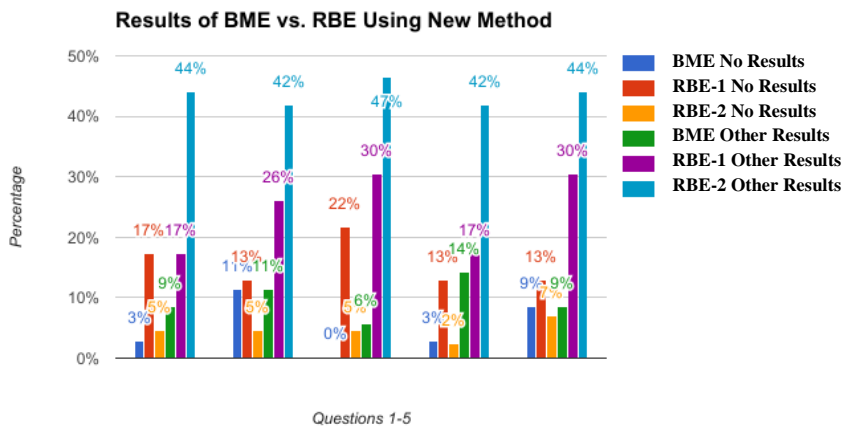


Figure 4: No and Other Results of

Different Versions of Second Implementation

1. Do you feel more confident in your ability to handle ethical dilemmas that may arise in your line of work?
2. Do you feel that the roleplaying enhanced your understanding of ethics?
3. Do you feel like learning different ethical theories will help you better identify ethical concerns that may arise in the workplace?
4. Did the role play help you see the connection between ethical theories and decisions in engineering?
5. Did you enjoy this activity?

Figure 5 shows the comparison between all of the percent yes data from all of the post-surveys from classes in which the team presented lessons using the second implementation method except this data excludes the other category answers. This allows for the comparison of net positive results between the classes, which all remain relatively the same from course to course.

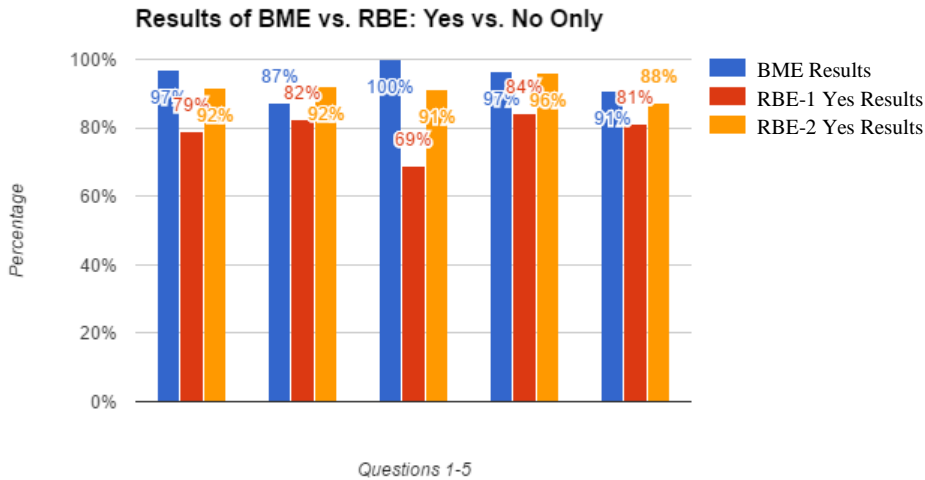
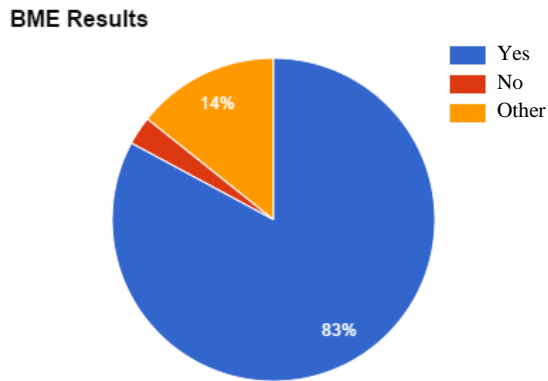


Figure 5: Results of Different Versions of Second Implementation Excluding Other

1. Do you feel more confident in your ability to handle ethical dilemmas that may arise in your line of work?
2. Do you feel that the roleplaying enhanced your understanding of ethics?
3. Do you feel like learning different ethical theories will help you better identify ethical concerns that may arise in the workplace?
4. Did the role play help you see the connection between ethical theories and decisions in engineering?
5. Did you enjoy this activity?

Figure 6 below displays the percentage of different responses to the question asking whether students could see the connection between ethics and engineering from the first lesson of the second implementation method in a biomedical engineering course. That data shows that most of the students felt that the activity did help them see the connection while very few, only three percent, felt that the activity did not accomplish this.

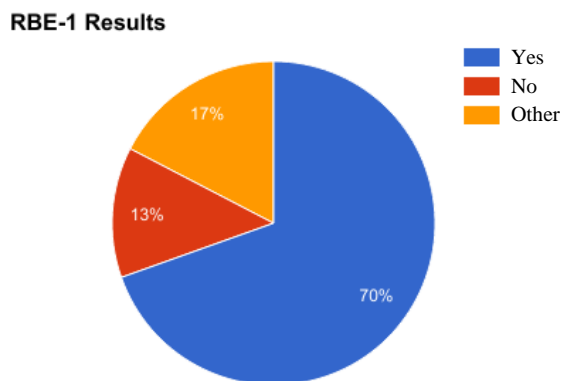




*Figure 6: Biomedical Engineering Second Implementation Connection between Engineering and Ethics Results*

Did the role play help you see the connection between ethical theories and decisions in engineering?

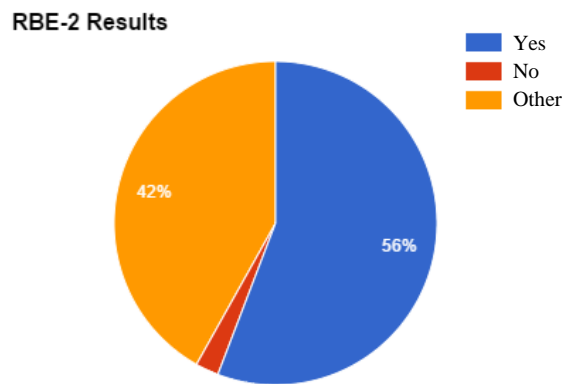
Figure 7 displays the percentage of different responses to the question asking whether students could see the connection between ethics and engineering from the first lesson of the second implementation method in a robotics engineering course. That data shows that most of the students felt that the activity did help them see the connection while ten percent more students than in the prior class felt that the activity did not accomplish this. The amount of students answering other also had a slight increase than prior.



*Figure 7: Robotics Engineering First Lesson Second Implementation Connection between Engineering and Ethics Results*

Did the role play help you see the connection between ethical theories and decisions in engineering?

Figure 8 displays the percentage of different responses to the question asking whether students could see the connection between ethics and engineering from the second lesson of the second implementation method in a robotics engineering course. That data shows that about half of the students felt that the activity did help them see the connection only two percent of students felt that the activity did not accomplish this. The amount of students answering other had a drastic increase from the other lessons to just short of half of the class.



*Figure 8: Robotics Engineering Second Lesson Second Implementation Connection between Engineering and Ethics Results*

Did the role play help you see the connection between ethical theories and decisions in engineering?

## V. DISCUSSION

### 5.1 The Role Playing Module: First Implementation

The first implementation of the lesson revealed several flaws with our initial idea theory of how to create this module. The first problems were found during the team's observations while presenting to the class. These problems consisted of struggling to get students to openly participate in the class discussion, the activity taking too long to complete, and the students seeming to view this activity as a design problem from an engineering mindset, not as a discussion of ethics. The first problem is a fairly common problem faced by professors that could be fixed by calling on people at random, hand raising, and other such techniques that the team looked into for the purpose of this module, like electronic clickers. The second problem was more or less just a flaw of the design itself and can be improved on through some techniques such as obtaining more time in class for the module and budgeting time better during the module. The last problem had to do with the activity itself, suggesting that the activity needs a stronger ethics education base.

The next set of flaws could be found in the surveys and these consisted of ineffectiveness in generating student interest, inability to get students to gain a firmer understanding of ethics education's connection to engineering, and the students' not thinking that the roleplay was an effective tool to help them understand ethics better. The first of these can be clearly seen by the fact that the questions of whether the students enjoyed the activity, if they would recommend it to a friend, and if they would consider taking a full course on BME ethics was only answered yes 62 percent, 56 percent, and 46 percent of the time respectively. This clearly shows that slightly over half of the students that participated really enjoyed the activity and became interested in pursuing more education on the topic of ethics. This meant that the team clearly needed to

develop a better way of generating interest in the topic, whether that meant having a more interesting case or a different style discussion was one aspect that needed to be tested. The next flaw can be easily seen by the fact that only 65 percent of the students felt that they could more confidently handle ethical dilemmas. This is a very similar issue to the issues found in observations of the class, the lesson needed a stronger ethics education base to get students to more fundamentally understand ethics and act comfortably on topics in which ethics are in question. The final flaw shown from the survey can be easily seen from the fact that on the question of whether students felt roleplay enhanced their understanding of ethics only 57 percent of the students answered yes. This problem showed that the structure of the roleplay itself needed to change so students would have to think about the ethics of their given role and their peers roles. All in all, this implementation clearly has shown that it has had several flaws that needed to be solved in order to develop a lesson that accomplishes what this IQP sets out to accomplish.

## **5.2 The Role Playing Module: Second Implementation**

The second implementation of the roleplay lesson achieved much better results than the first. The first improvement made was the to fix the length of the presentation itself which was a simple enough fix of better time planning and management. Even with this increase in interest, the problem of getting increased class participation in class discussion was still a problem, but had improved upon a bit from the last implementation. This issue may require calling on students at random to fix, however the team is hoping that in increasing interest and enjoyment of the activity that this problem will just be sorted out by itself. The team then found that this implementation was also much more successful in increasing the students' comfort in their

ability to handle ethical dilemmas in the workplace due to how 89 percent said they were capable in this implementation, which was a large increase from the 65 percent that said yes to this question in the first implementation. The team believes that this is largely in part because of the direct teaching of ethical theories which 94 percent of the students said would be helpful in identifying ethical concerns in the workplace and because 77 percent of the students said that they did feel that roleplay was a useful tool in increasing their understanding of ethics, which is a 20 percent increase over how many students said yes to this in the last implementation. The fact that still only about three quarters of the students felt that the roleplay specifically was a useful tool means that this is still an aspect the team needs to improve upon, but the project has definitely taken a step in the right direction. The next improvement the team found from the last scenario was that, unlike what was observed during the last implementation, that 83 percent of the students felt that they could see a connection between ethical theories and decisions they may have to face in engineering decisions. The team also observed that the student's individual discussions in groups was much stronger than in the prior implementation with a much more clear focus on the ethics of the given scenarios themselves over the engineering aspects. Even students who came unprepared, which is a problem the team hopes to fix by giving the students much more notice and time to read the pre-handout, were caught up early in the group discussions and were able to learn and contribute during the activity.

### **5.3 The Role Playing Module: Second Implementation Biomedical vs. Robotics**

The first major difference between these results the team noticed was a large increase in the uncertainty of responses, increase in the number of students who answered something other than yes or no, between each of the second implementation lessons, as shown in figure four.

There is a couple theories that the team has been looking into in order to explain this occurrence, the first of which is the time allotted in each of the lessons. The lessons each time had less time available than the one prior, from about 40 minutes, then to 30 minutes, and finally about 20 minutes. This means that the student had less and less time available to them to discuss the topics and less time for the presenters to hold discussion with the class which could mean that by the end the students may have been unable to fully air their thoughts and for discussion, thus making the activity less impactful for them. The students also might have just not had enough time to really reflect on the activity itself and give a solid answer on whether they felt the activity had been beneficial to them or not. Another theory for the increase in uncertainty is that the activities became more successful at challenging students opinions and getting them to think more in a more indepth fashion about their pre-held thoughts on ethics which, despite being a harder metric to measure by, is also a positive result for most ethics exercises. This thus resulted in the students being less sure in their own ethical standings and thus not as certain on how the activity affected their previous notions. This theory can be fairly well supported by how students often wrote longer more thought out answers to the questions that were not quite as positive or negative, but more self reflective as the amount of uncertainty in answers increased. An example of this was how one of the student stated in one of the surveys that it “forced me to look at a situation from a different point of view” and it “made me better at thinking critically.” This is a perfect example of why roleplay was a great tool here. It helps to bridge the gap between real life and theory, which is exactly what roleplaying is intended to do [28]. That is just one possible example and there are many more that have been received on the surveys about how the student felt that they are less concrete on their opinions and more likely to think about others’ perspectives. Finally, the team also decided to analyse the results from these different lessons

excluding the other results to see the net positive results, as shown in figure five. These results showed that the percentage of students answering positively vs. negatively was very close on average between each of the courses' surveys.

#### **5.4 General Discussion**

The team sought to develop the most effective lesson to help students bridge the gap between ethics and engineering and this method has shown to be quite successful with upwards of 83 percent of students in an individual lesson giving a definitive yes when asked about this topic, as shown in figure six. The lesson got students talking and working together. During the activity team members would go around the room and answer questions and listen to conversations and some students were actively roleplaying, stating that “from their moral perspective they would likely believe blank”, and when confused about what their theory would value as important they would often ask us questions. This conversation was great, it allowed people who may believe in a theory to argue for it without the fear of having their views looked down upon by someone who values different ethics. It also allows those same people who value different ethical views to consider some opposing outlooks and see their reasoning and how each theory affects people. While most students did not go into the class thinking they followed any particular ethical theory many of them saw correlations by the end. Some students even seemed as though they took the lesson to heart and looked as though they were going to be thinking more about the end results of the products they eventually design.

A current problem that exists with this model, despite it's success, is how difficult it is to create and implement. The lesson trades off ease of use for the presenter in exchange for effectiveness of the activity, which could be a problem. Despite it showing more positive results than other methods it may not be used due to how challenging it can be to use. This problem is one that the team has been well aware of, but decided to work towards the current activity structure despite the drawbacks. Initially the team wanted to focus on the creation of a way to make ethics lessons extremely easy and available, but these types of lessons often failed to actually be able to address

the gap between engineering and ethics. Due to this, the team decided to focus on prioritizing of the quality and effectiveness of the activity instead of how much easy it is to use it in teaching. Then, once the activity had been proven successful, the team will try to simplify down the activity without losing the activity's effectiveness. The team was unable to get to a point in which the project could go through testing of simpler variations, but that could be a future endeavor of another team. While the lessons were shown to be very successful, each required research on ethical theories, a case study relating to the general class and in depth knowledge of how each of the theories would relate to a portion of the case study. That requires a lot of pre-planning, time investment and research to set up. While we know professors are all experts in their relative fields, not all engineering professors are ethical experts and not all engineering professors have time to research ethical theories and find a good case study that can relate them in a way that focuses less on engineering and more on ethics. Our own team had trouble with this despite many hours of research into ethics and the courses we were presenting to.



## **VI. FUTURE RECOMMENDATIONS**

The role play method developed by the IQP was shown to yield fairly successful results, but there are still several improvements that can be made to the method in order for it to be more efficient and effective. The current lesson design can be difficult to replicate, making it much harder for professors to include in their class should they desire to have the students participate in it. Due to this, the first recommendation would likely be attempting to make the method either simpler or made in such a way that makes it much more easy to create the individual class lesson and reading and still be relevant to the class. Another aspect that could be worth looking into for this method is determining which ethical theories are optimal for this activity, as during this project the same five theories, social contract theory, rule consequentialism, act utilitarianism, kantianism, and moral relativism, were used for each lesson. Finally, future teams could look into the long term impact of the activity as past teams did. Our team did not really successfully track and measure if the in class modules were useful and relevant to students after an extended period of time.

The team would also like to make a few general suggestions for any future teams working on similar projects. The first of these would be attempting to target smaller classes primarily, especially if using a more active teaching method as our group often found these lessons to turn out much better. Secondly, future teams should try to get as much time as they can in classes for their lessons as the less time our team had to perform the activity, the less decisive the students became and more likely the students were to be unsure if they actually got anything out of the activity. The team strongly recommends that teams should try booking classes for their module as soon as possible in order to maximize time they get and ensure they are solidified in the syllabus. Teams should also try as hard as possible to get the activity to be graded for participation as student attendance was much higher in classes that did have the activity worth some amount of points. Lastly, the team would like to recommend that future teams figure out the metric by which they are measuring the success of their lessons, such as how this activity was measured primarily by the students' answers to survey questions about their

ability to see the connection between ethics and engineering. This should be done as early as possible, because that helps significantly with determining the direction of the project.

## **VII. CONCLUSION**

The engineering students currently attending Worcester Polytechnic Institute will be required to be able to identify and address ethical dilemmas that may arise in the workplace. These students however are not required to take a full ethics and since they still need to learn about ethics they often have ethical teachings incorporated in their engineering classes. It is often very difficult to incorporate ethics education into engineering courses. The ethics education these students receive also often fails to succeed in getting students to see the direct relationship between ethics and their major. Our team's developed roleplay module is capable of successfully countering both of these issues by having a set structure that can be run by anyone even if they are not an expert on the topic of ethics, despite being a bit difficult to create, and has been shown in the engineering classes we have gone into to successfully enable students to see the connection between engineering and ethics.

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**IX. APPENDIX:**

**9.1 Appendix A: Surveys**

**Figure 9: First Implementation Ethics Roleplay Survey**

Role: \_\_\_\_\_

Features	First Column	Second Column	Third Column
Accuracy			
Cost			
Non-Invasiveness			
Chance of Complications			
Ease of Use			
Battery Life			
Backup Safety Systems			
Compatibility			

1. Do you feel more confident in your ability to understand ethical dilemmas that may arise in the design process?
2. Do your feel that the roleplaying enhanced your understanding of ethics?
3. Would you recommend this activity to a friend?
4. Did you enjoy this activity?

5. Would you consider taking a full (1/3 credit) BME ethics course?



**Figure 10: Second Implementation Ethics Roleplay Survey**

Ethical Theory: \_\_\_\_\_

Factors	First Column	Second Column	Third Column
Absence of Alternative Treatments			
Time to Finish Testing			
Adherence to FDA Regulations			
Reduction of Risk to Test Subjects			
Absence of Local Restrictions on Testing			
Minimizing Cost of Testing			

1. Explain your justification for how you ranked the third column(if you need more room please use the back of the page).

2. Do you feel more confident in your ability to handle ethical dilemmas that may arise in your line of work?

3. Do you feel that the roleplaying enhanced your understanding of ethics?

4. Do you feel like learning different ethical theories will help you better identify ethical concerns that may arise in the workplace?

5. Did the role play help you see the connection between ethical theories and decisions in engineering?

6. Did you enjoy this activity?



## 9.2 Appendix B: Pre-Reading

### Figure 11: Second Implementation BME Ethics Pre-Reading

#### Ethics IQP Roleplay Pre-Reading

##### Intro

\_\_\_\_\_ We are currently an IQP team working to introduce more ethics education into engineering classes. How we are going to do this with your class is by doing a little roleplay module in which each student will roleplay as a given ethical theory and discuss the given case study. Ethical theories are different ways to think about and determine the morality of any given scenario. We would like you to read over the case study and the ethical theory assigned to your group and for you to attempt to come up with answers to the discussion questions given by your assigned theory prior to arriving in class. You do not have to write anything for the discussion questions themselves, just think about the questions and be prepared to discuss. This should help you gain a better understanding of your given ethical theory and how it may address the given case so that you are more comfortable discussing this topic in class. The only thing we would like you to fill out and bring in to the class is the rankings column from after the case study.

##### Case Study

The clinical trials and testing that a company has to go through in order to get a medical device approved by the FDA, Food and Drug Administration, for use in the United States can be an extremely expensive and time consuming process, involving preclinical research and direct approval by the FDA before use [34]. As a way to attempt to cut back on the time required to get a medical device approved, many companies will take their product to the developing world and perform human trials much sooner and faster than they could in the United States. This is because the FDA still accepts results obtained in foreign countries clinical trials. This allows them to get their medical device to be useable in the United States much sooner which could save lives of people that could have not had access to the device if they did not circumvent the FDA regulations. This can also be a beneficial arrangements for the third world as it gets people treatments that they otherwise could not get or afford that may save their lives, but this also means that the treatments being provided to this people are often extremely experimental.

The scenario we will be talking about in your class is going to be the clinical trials of a device called the wound pump in Rwanda [35]. The wound pump is a simple mechanically powered device developed to be a low cost way of removing fluid and alleviating pressure from a wound area to expedite healing. It has been tested in Rwanda and is currently undergoing testing for trials in clinical use. In theses third world countries most typical wound pumps have been limited by electrical power, as most are automated, or by expensive and intricate pieces like springs. Testing in Tanzania for a similar pump failed when the springs caused the pump to be

too expensive for general use by the population. This new low cost wound pump could potentially help many people if the clinical trials go well.

Based on what you have learned, please fill out a ranking for each of these, 1 being most important to consider and 6 being of least concern. Please bring a copy of your ranking into class either on a scrap piece of paper or printed out. If you are unsure on any factors please fill it out to the best of your ability, we will discuss more in class Monday.

Factors	Rankings
Absence of Alternative Treatments	
Time to Finish Testing	
Adherence to FDA Regulations	
Reduction of Risk to Test Subjects	
Absence of Local Restrictions on Testing	
Minimizing Cost of Testing	

## **Group #1: Social contract theory**

“Social contract theory, nearly as old as philosophy itself, is the view that a person's' moral and/or political obligations are dependent upon a contract or agreement among them to form the society in which they live [36].”

The theory believes that all humans are naturally selfish, but since all other humans are also inherently self interested, they will agree to a “social contract” in which rules are placed to keep other humans from doing bad. The idea is that if everyone agrees to a said “social contract” that all individuals can still pursue their own interests within a set of rules that keep each individual from harming one another. “According to Hobbes, the justification for political obligation is this: given that men are naturally self-interested, yet they are rational, they will choose to submit to the authority of a Sovereign in order to be able to live in a civil society, which is conducive to their own interests [36].” The role of the “Sovereign” in this is some enforcement of the social contract. Usually this is represented by a government, as they are typically the one’s to punish people if they murder, steal or do anything else to harm other humans for their own benefit. Hobbes argues that without a social contract humans would revert to their base selfish nature, which he calls “The State of Nature” (though he admits this is hypothetical) in which “men are naturally and exclusively self-interested, they are more or less equal to one another, (even the strongest man can be killed in his sleep), there are limited resources, and yet there is no power able to force men to cooperate [36].” In this state with no cooperation nothing would get done and the reason people agree to the social contract is to prevent a return to the “State of Nature” to preserve their own lives.

In applying social contract theory to the wound pump case study, one can see that the moral conclusion depends on which version of the theory you are supporting. The idea is to follow the social contract which is usually the laws of the government, but whose laws do you follow in this case? Field testing on subjects is allowed in Rwanda [35]. In the US this testing would have not been allowed, but is the loophole to allow testing in third world countries there on purpose and therefore meant to be exploited or not? Social contract theories have the assumption that these laws are in place to serve the self interest of each individual. The case study mentioned that the wound pump will provide cheaper medical treatment that does not use electricity which is in the interest of people [35]. However, what if the law prohibited field testing which provides the treatment for people who are in need and increases the speed in which the product will reach final development? Are breaching the laws then the moral thing to do? Is a society with bad laws better than a lawless society? These are all questions the student needs to have in mind while deciding on what is ethical.

## **Group #2: Rule Consequentialism**

Consequentialism states that “Whether an act is right or wrong depends only on the results of that act [37].” Rule Consequentialism takes this a bit further stating that “An action is morally right if and only if it does not violate the set of rules of behaviour whose general acceptance in the community would have the best consequences--that is, at least as good as any rival set of rules or no rules at all [37].” The same idea from consequentialism is there, but Rule Consequentialism has guidelines if you don’t know how something will turn out. For example not murdering is generally a good rule to follow, however in some cases you can justify it, in Rule Consequentialism this would be a rule that you should try to follow unless you know for certain that murdering someone will bring about a better result. The rules adopted are usually very general as they are rules that if everyone followed it would always be good. Some examples of common rules are don’t lie, don’t steal, don’t murder. But while these are defined as “rules” they can be broken if you know with complete certainty that breaking the rules will result in a better outcome.

In this case study, when a rule consequentialist approach is taken, one would have to try to determine if the outcome of the experimental clinical trials are more beneficial results than any negative impacts that may come out of it. Do you think that this scenario has a net positive result or not, and why? In partaking in developing world clinical trials it can be considered exploiting a loophole in FDA testing requirements by performing human trials earlier than their regulations would have you do it in first world countries. Would you consider this as breaking a rule in Rule Consequentialism? If so would you say that the benefits that could arise from this scenario could make it morally positive, despite the rule being broken?

### **Group #3: Act Utilitarianism**

Act Utilitarianism is the moral principle of acting with the ideal of doing the most good. In other words, an action is correct if it brings about the greatest amount of happiness among the greatest number of people [38]. It states that there is no real moral good or bad that can be judged except by the outcome of total happiness. It can justify killing someone to save many people, stealing from someone to help more people and so on and so forth. In this theory the only thing that matters are the consequences of the act.

For the case study act utilitarianism can view it as a good thing, for as the tests were done on people it allowed the technology to not only help those people but also to rapidly move the device up to clinical tests so it can help more people sooner. Even if the device had caused harm to some people, if the net gain was that the device got to more people sooner and in total helped people more than it hurt people it would be considered the morally correct choice. Do you think that the wound pump testing results in a net good for the Rwandans? Is it more or less net good if the rest of the world is brought into the scope? Would you consider the experimental human testing in Rwanda to be ethical from an Act Utilitarian perspective?

#### **Group #4: Kantianism**

Kantianism is a moral theory based on the ideals of the German philosopher Immanuel Kant. It states that certain actions are prohibited (like murder and theft) regardless of whether these actions would produce a net gain of happiness. These are regulated by ideals upheld by the person, which are called imperatives and things you do according to those rules called maxims [39]. As a point of reference in Kantianism one should "Act only on that maxim through which you can at the same time will that it should become a universal law [of nature] [39]". This theory argues that strict moral codes must be adhered to and that people should not ever act out selfishly. For example, if in your code of ethics you could not eat skittles, then you should never be allowed to eat skittles even if that benefits you or those around you. This ethical theory is focused more around duty than end goals. It also considers the base value of human beings and humanity as a whole. As a result Kant states "So act as to treat humanity, both in your own person, and in the person of every other, always at the same time as an end, never simply as a means [39]." This means humanity must always be the end result benefactor, not simply as a motive for personal research. This theory follows deontological moral theories which state "the rightness or wrongness of actions does not depend on their consequences but on whether they fulfill our duty [39]."

In context of the case study, a Kantianist must ask themselves whether testing on humans is justified and at what stages. The device was already tested on humans in some places before it was approved for use in others, and in Kantianism, which follows universal rules, you must decide whether or not this is a good universal rule to have. If you think that it is justified then you can justify testing more dangerous products on people, but if you don't think it is justified then the product would not have been used in these third-world countries and may have taken longer to get to the testing phase it is in now. Also it was tested on humans, was this for the good of humanity, or did the company treat humans as a means and not an end?

If you knew someone dying of a disease that an experimental procedure could potentially cure, would you want that procedure done? What if you knew that if the procedure failed said person may develop worse symptoms? What do these situations have to do with the Kantianist mindset?



### **Group #5: Moral Relativism**

Moral Relativism is defined as “the view that moral judgements are true or false only relative to some particular standpoint (for instance, that of a culture or a historical period) and that no standpoint is uniquely privileged over all others [40].” This ethical theory argues that each culture can have radically different sets of morals than each other and that there is not universal set of morals shared by all humans. Moral Relativism thus states that cultures should avoid judging the morals of each other’s practices or beliefs [40].

In the context of the given case study, someone adhering to the moral relativism would have to try put themselves in the shoes of the people Rwanda being tested upon as human. In trying to think from the perspective of the local people, would you want to be a part of the testing of the wound pump should it claim to help you with an injury you may have? This treatment would be experimental, but it would probably be better than any other treatment you would have access to, so should it work as intended than it would be quite beneficial. Would you, as a native Rwandan, consider the human experimentation of this product in your country as something moral?