AN ABSTRACT OF THE THESIS OF

Torri E. Rinker for the degree of Honors Baccalaureate of Science in Bioengineering presented on May 4, 2009. Title: The Effect of an Ethics Course on Bioengineering Students' Understanding of Social Justice Issues in the Context of Engineering.

Abstract Approved:

_____

Michelle Bothwell

The nature of engineering work requires that ethical considerations are taken into account while making decisions surrounding topics such as technology, equal distribution of cost benefits, and consumer risk. In order for engineers to make ethical decisions in their careers, it is helpful if their engineering education provided them with a solid understanding of ethics. Social Ethics in Engineering (BIOE 420) is a required course within the bioengineering curriculum at Oregon State University that covers ethical considerations within the context of engineering, emphasizing connections between engineering practice and social justice. In order to understand the effects of such a course on bioengineering students' understanding of ethics in engineering, semi-structured interviews were conducted with twenty students that had taken the course. The interviews were transcribed and then analyzed for common themes. Seven themes were found, a few of which include students' feelings regarding course importance, ideas surrounding moral and ethical development, and personal connection with the course. Student responses revealed that most students found the course as a valuable and unique part of their engineering education and that some students have already begun to implement parts of the course into their every day lives.

Key Words: Engineering, Ethics, Social Justice, Education

Corresponding e-mail address: torri.rinker@gmail.com

©Copyright by Torri E. Rinker
May 4, 2009
All Rights Reserved

# The Effect of an Ethics Course on Bioengineering Students' Understanding of Social Justice Issues in the Context of Engineering

by

Torri E. Rinker

A PROJECT

submitted to

Oregon State University

University Honors College

in partial fulfillment of
the requirements for the
degree of

Honors Baccalaureate of Science in Bioengineering (Honors Scholar)

Presented May 4, 2009
Commencement June 2009

Honors Baccalaureate of Science in Bioengineering project of Torri E. Rinker presented on May 4, 2009.

APPROVED:

_____

Mentor, representing Bioengineering

_____

Committee Member, representing Bioengineering

_____

Committee Member, representing Women Studies

_____

Head, Department of Chemical, Biological, and Environmental Engineering

_____

Dean, University Honors College

I understand that my project will become part of the permanent collection of Oregon State University, University Honors College. My signature below authorizes release of my project to any reader upon request.

_____

Torri E. Rinker, Author

## Acknowledgements

First and foremost, I would like to thank Michelle Bothwell. Michelle was not only my mentor for this thesis, but an inspiration during my years at Oregon State University. I learned a great deal from her strength as a person, her genuine care for other people, and her ability to overcome challenges. I consider her not only my academic advisor, but a friend that I hope to have for years to come.

Secondly, I would like to acknowledge Susan Shaw for her guidance in the data collection, data analysis, and writing of my thesis. As I had not conducted this type of qualitative research before, Susan gave me lessons about how to go about things from the beginning. I would also like to acknowledge Joe McGuire for his assistance on my thesis committee. Joe has been a great mentor and professor to me through the years, as well as a friend.

Thirdly, I would like to acknowledge my parents, Mike and Jan Rinker. Without their support, I would not be at Oregon State University and I cannot thank them enough for all they have done for me. They have encouraged me to do my best since I was two years old and have always pushed me make the most out of any situation. I want to thank them for their patience when I am too busy to get a hold of and for the continued care and love they give me every day.

I would like to thank all of the bioengineering students who participated in my thesis interviews. Without their cooperation and willingness to divulge information about their lives, this study would not have been possible.

Lastly, I would like to thank Caslin Gilroy and Brian Maloney. Brian has been a wonderful person to share ideas with social justice about and someone who believes that engineers should promote social justice. Caslin has been a constant source of support, fun, and intellect since the day I stepped on the OSU campus. She and I began discussing social justice issues in engineering nearly the first day we stepped into BIOE 420 and have not stopped since. Together, we have held one another accountable for our actions regarding ethics in engineering. I consider her one of my best friends and know we will continue to share our experiences in science and engineering for years to come.

# Table of Contents

The Effect of an Ethics Course on Bioengineering Students' Understanding of Social Justice Issues in the Context of Engineering

# Introduction

Traditional engineering curricula are heavy in technical courses while relatively light in humanities and social studies courses. Upon graduating, engineering students tend to lack an understanding of social systems of oppression and privilege, which are dominated by, identified with, and centered on privileged groups (Johnson, 2006). In particular, they do not understand how the social systems present in society relate to the oppression that is prevalent in our country. In order for students to have knowledge of such issues, they must engage in courses that cover difference, power, and discrimination (Bothwell, 2007). Otherwise, engineering graduates will struggle to be culturally competent engineers and citizens.

In their work, engineers face many issues that require an understanding of how social injustice is perpetuated. Social injustice is the phenomena in which social systems of oppression cause people outside the privileged group to experience unjust situations in comparison to the privileged group. Social systems of oppression can affect how engineering decisions are made, as they can sometimes cause one group of people to be dealt disproportionately more negative consequences than the groups who benefit from the decision. Those groups of people tend to be marginalized groups in society, or groups of people who fall outside of the dominant paradigm and privileged groups. For example, often the hazardous waste generated in various engineering processes is disproportionately dumped on land occupied by marginalized groups. A study by the United Church of Christ Commission for Racial Justice found that three out of five African-American and Hispanic

Americans live in communities with uncontrolled hazardous waste sites (Whitbeck, 1998). Furthermore, many of the worst waste sites in the US that primarily affect the health of people of color in the South have received little attention (Whitbeck, 1998). Hazardous waste exposure is only one of the many examples of how marginalized groups in the US are treated unfairly in engineering decision making.

The culture created by the dominant paradigm in engineering, middle-class white males, often makes it hard for others outside of these social categories to participate in the profession. Those outside of the paradigm do not always feel that they "fit in." For example, the engineering career path is demanding. Professionals are often expected to work over forty hours a week, which can take time away from outside activities. The engineering educational experience is also very demanding. Students who have not had the privilege of a strong high school education in math and science will find themselves behind their colleagues in the university setting. As education disparities in our country have strong divisions across ethnic and economic lines (Children's Mental Health, 2009), this phenomenon can act to eliminate an entire group of people from the field of engineering. This discrimination occurs due to the demands and expectations of the field as a whole, which only take into consideration how much a student "should" know when entering an engineering program. How much a student "should" know is based on what a privileged student in the US is able to gain in an ideal educational environment. These issues can be combated by engaging students in discussion of the issues surrounding oppression and privilege (Bothwell, 2007). Once exposed to the systems of injustice that they work in, engineers will have more of an understanding of how their career choices can either perpetuate such systems or break them down.

Social Ethics in Engineering (BIOE 420) is a required course within the bioengineering curriculum at Oregon State University and one of the few courses in the nation that addresses oppression and privilege in the context of engineering (Bothwell, 2007). The course is structured so that the first half focuses on sociological and philosophical concepts and the second half focuses on how systems of oppression impact both engineering education and practice. Specifically, the course addresses social construction of difference, social systems, oppression, privilege, strategies used to deny the need for and to resist social change, and the ways to promote social change (Bothwell, 2007). During the course, roots of oppression and privilege are exposed, giving students an opportunity to see the world from a new perspective. The students can see that the problems discussed are linked to social systems of oppression, of which we are all a part of and which we all play a role in maintaining. Students are shown that engineers can be involved in these systems through unfair distribution of cost and benefits, lack of informed consent, and the use of physical characteristics and values of an average person in the dominant paradigm for product design criteria (Bothwell, 2007). For example, students are exposed to the idea that toxic waste sites result in unfair distribution of cost and benefits, as these waste sites are often disproportionately in areas where marginalized groups reside. They discuss the Tuskegee study, in which black males who had syphilis were studied without their knowledge, thinking they were only going to the doctor for treatments (U.S. Public Health Service Syphilis Study at Tuskegee, 2009). This is an example of the privileged group, the doctors, providing no informed consent to the marginalized group, the black males with syphilis. To understand how physical characteristics and values of an average person in engineering are used to make

engineering decisions, students are given the example of seatbelts. If the dominant paradigm group in engineering, consisting of white males, only made seatbelts to fit the size of one of its typical members, the safety of smaller people would be compromised. They are also taught that the dominant paradigm in engineering can unintentionally function to keep those outside of the dominant paradigm out of engineering.

To further study the effects of a social ethics course on engineering students, we conducted individual semi-structured interviews with twenty bioengineering students at Oregon State University who completed BIOE 420. Previously, we had noticed that many engineering students at OSU seem apprehensive about taking ethics courses, viewing them as a waste of time and irrelevant to their careers. Not all engineers feel this way, however, and this research was conducted to determine how a social ethics course offered through an engineering student's department of study can impact his or her understanding of ethics in an engineering career. For those impacted by the material presented in this course, we were interested to see how this course caused them to view the topic of ethics in their future career. Given our data, it is possible to propose improvements to the course so that more students will be engaged in the material covered.

# Literature Review

### The importance of ethics in the field of engineering

The work of engineers is ubiquitous in society. Engineering innovation and creation impacts the public on a daily basis. Due to the nature of their work, it is imperative that engineers have a strong understanding of the ethical considerations and responsibilities that come along with it. Recent events, including phenomena like global warming, unjust distribution of health care, and unacknowledged conflicts of interest, have led to an increased awareness in the science and technology communities of the need to highlight "responsible conduct and ethical behavior," (Bird, 2003). Each profession, engineering included, has a unique set of ethical guidelines based on its specific responsibilities (Whitbeck, 1998). As Whitbeck notes, for engineers, "professional responsibility is such a demanding subject because the exercise of responsibility typically requires the exercise of discretion and consideration of many technical matters and matters of value," (Whitbeck, 1998). She continues by noting that "ethical and technical considerations frequently become inextricably intermingled" in the context of professional engineering decision making. This idea is highlighted by Kline, who discusses that for engineers, professional responsibilities include specialized knowledge, autonomy, and social responsibility (Kline, 2002).

Both the mix of professional responsibilities and the ever-increasing impact of engineers in global and societal contexts have led to a realization that it is vital for engineers to have less of a one track mindset focused on the technical aspects of work and more of a broad outlook that encompasses societal considerations (Newberry, 2004). Such societal considerations are critical, as the solid lines that once divided science and engineering from society are

beginning to blur. In fact, Williams claims that “engineering has evolved into an open-ended Profession of Everything in a world where technology shades into science, art, and management,” (Williams, 2003). To determine if hypothesized ethical situations truly arose within the engineering field, a group of practicing engineers was surveyed and asked to indicate if they had faced “an ethical issue” in the course of their engineering practice (Bird, 2003). It was found that 53-70% had, showing that “competence in recognizing and addressing ethical concerns is a basic skill for science and engineering professionals,” (Bird, 2003). Not only is it important for engineers to have social awareness because of their impact on society, but also because of the social component of their work (Kuhn, 1998). Engineers should try to integrate the “social world of discussion, negotiation, and cross-disciplinary collaboration in engineering design practice,” (Kuhn, 1998). Integrating social awareness into technical discussion is necessary in order for engineers to make good decisions and work in teams. It is apparent that ethical considerations and social awareness play a significant role in the engineering field and that it is necessary for responsible professional engineers to take them into account.

It is also important that engineers consider the ethics behind their work because, while speculation is critical, it is impossible for them to actually know how their innovations will function socially and technically once in the hands of their users (Kline, 2002). Similarly, Karl Stephan has noted that “the products of engineering affect more people in a larger variety of ways than ever before, and many of these effects are increasingly difficult for the responsible engineer to anticipate,” (Newberry, 2004). They also do not know their long term social implications (Kline, 2002). To combat many of these unknowns, it is important that

engineers monitor the consequences of their work and be certain that consumers are fully informed about the products they are using (Kline, 2002). It has been suggested that engineering is something of a "social experiment," as engineers observe public reaction towards the products they create and modify accordingly (Kline, 2002). Ethics must be upheld throughout this process so that consumers are protected even in the midst of all of the unknowns.

In order to show the public that engineers care about the ethical ramifications of their work, engineering societies began to establish codes of ethics to improve public image (Kline, 2002). Such professional codes are in place "to protect each professional from certain pressures…by making it reasonably likely…that most other members of the profession will *not* take advantage of her good conduct," (Davis, 1991). These "certain pressures" refer to the temptation to cut corners and reduce the quality of work in order to make products cheaper and faster. An engineer's ethical beliefs are justified, upheld, and enforced through the engineering codes. Without codes, an engineer could have personal objections to a particular process or problem, but without a professional obligation, such as a code, he or she would have nothing to point to justify the objection. This engineer would then risk losing his or her job to another engineer who did not personally object. The codes eliminate this risk by integrating ethical considerations into the professional aspect of engineering (Davis, 1991).

**Typical engineering approach to ethics**

The views held by engineers regarding ethical issues and concerns are diverse. Some believe that engineering ethics cannot be fully developed until faced with ethical considerations in

the field (Harris, 2008). From this viewpoint, it is unlikely that a recent graduate from an engineering program would “manifest professional virtues to the fullest extent,” (Harris, 2008). This hypothesis is evident in an example where one engineering student comments that it is easy to get caught up in the technical demands in an engineering education until you “see this other side of the coin,” (Kuhn, 1998). This student realized that the “other side of the coin” involved seeing the “humanistic side of things”, which he believed made it harder to make engineering decisions due to the number of considerations that had to be made beforehand (Kuhn, 1998). Ethical development in engineers is often seen as a dynamic process and not an immediate revelation.

It is also thought that engineers should have the skills and ethical abilities to consider societal and technical demands simultaneously (Kuhn, 1998). Traditionally, engineers deal with such demands indirectly and rely on “ ‘technical norms’ rather than…dialogue,” which often does not cater towards successfully taking both the societal and technical sides into account (Wagner, 1993). Engineering ethics can be seen as a combination of technical virtues, or those sensitivities related to the technical side of engineering, and traditional moral virtues (Harris, 2008). However, it seems that often the traditional moral virtues are left out in ethical decision making (Harris, 2008). In other words, when making engineering decisions, engineers often only focus on aspects of ethics such as engineering codes rather than the morals that they hold themselves accountable to in their personal lives. Another trend that has been observed in regards to neglecting ethics involves engineering faculty. It has been observed that engineering faculty simply carry out the research and then leave it to others to

see what comes of it (Newberry, 2004). Though engineers may be fully aware of ethical issues, they often lack the tools and training necessary to deal with them.

The approaches that engineers take toward dealing with ethical dilemmas vary. Just as personal satisfaction can be derived from adhering to personal ethics, so can professional satisfaction come from holding to professional ethics (Harris, 2008). Furthermore, Harris believes that engineers should have techno-social sensitivity, respect for nature, and a commitment to the public good (Harris, 2008). A techno-social sensitivity involves an understanding of how technology affects society and how society in turn affects technological evolution (Harris, 2008). As engineers have a hand in creating almost all of the new technology in society, it is incredibly important for them to understand how it will impact the consumer and how its creation was influenced by the consumer demands in the first place. One engineering student echoes this in a study, as she mentions becoming aware that the creation and implementation of technology is never just a technical process, but often very politically charged (Kuhn, 1998). Commitment to the public good is important in any profession, but especially in one that affects the public as much as engineering.

Some argue that a code of professional ethics is all that engineers need to deal with ethical decisions. Davis states that the code is central to "advising individual engineers how to conduct themselves, to judging their conduct, and ultimately to understanding engineering as a profession," (Davis, 1991). Still, Davis argues that these codes should not be followed out of a promise made to an organization or because society says so. Rather, the codes should be seen as something rational to support. Engineers should understand that the codes require

some interpretation with an understanding of what the authors intended to get across when writing them (Davis, 1991). Many agree, believing that engineering ethics must go beyond holding to the engineering codes. Gorman mentions that while codes facilitate wisdom and ethical development, it takes a certain amount of moral imagination to make truly wise engineering decisions (Gorman, 2002). In his definition, moral imagination requires three things from engineers: engineers must 1) understand the mental model that dominates their view of the situation and understand the moral conflicts that could potentially rise from this; 2) have the ability to imagine other mental models; and 3) evaluate both mental models in light of the moral and ethical consequences (Gorman, 2002). He goes on to suggest that as ethical considerations are often made in teams, it would be beneficial for philosophers and engineers to collaborate and work together to solve ethical problems inherent to engineering practice. Kline highlights six major issues that engineering ethics codes revolve around, including public safety and welfare; risk and the principle of informed consent; conflict of interest; whistleblowing; trade secrets; and accepting gifts (Kline, 2002). While valuable, he notes that they are lacking. They do not cater towards cross-cultural interaction or give any insight on engineering managerial expectations (Kline, 2002).

One approach that has been highlighted by several different people is for engineers to treat engineering ethics like a design problem. Similar to design problems, ethical problems often have several constraints that must be met simultaneously. They also have no “right” answer, but rather have a variety of possible solutions that satisfy all the requirements, though some better than others (Whitbeck, 1996). Whitbeck outlines how requirements for solutions to design problems can be applied to solutions for ethical problems (Whitbeck, 1998). Solutions

must 1) achieve the desired end; 2) meet criteria; 3) be reasonably secure against accidents; and 4) be consistent with background constraints (Whitbeck, 1998). Approaches to engineering ethics can involve a focus on thoughtful contemplation rather than strict adherence to specific rules (Lynch, 1998). Such an approach caters nicely to seeing ethics as a design problem, as creativity and reflective thought are necessary. Ethicists also generally agree that focus should be on realistic cases and practical action that engineers can take in such cases (Lynch, 1998). They believe that it is best to consider ethics within engineering problems rather than focusing on abstract moral justification (Lynch, 1998).

**Students' receptivity to ethics education**

While the significant foundation upon which ethical views are built is laid during childhood, changes and additions to a person's ethical views can occur throughout life. Hursthouse suggests that certain virtues, like a respect for nature, cannot be simply adopted but must rather be acquired in childhood (Harris, 2008). However, as James Rest expresses, this does not negate the need for ethics education. He states that changes in problem solving strategies used to deal with ethical issues occurs from the ages of 20-30. Furthermore, he claims that this change is proportional to the amount of education a person has had and that education with the purpose of raising awareness about moral issues successfully changes student ideas (Velasquez, 1987). University course work is the type of education necessary to induce a shift in views for engineering students. In addition, as mentioned by Makkai, research has shown that the surroundings of an individual impact held values. It follows that "university instruction, as well as subsequent professional life, can play some role in shaping values," (Newberry, 2004).

It has been proposed in theory and proven in practice that a true understanding of the social demands on engineers does not occur until engineers are faced with a situation that involves such considerations. In one study, interviews of two students suggested that they were hit by a moment of insight, during which the importance of the material provided to them through ethics education finally clicked (Kuhn, 1998). This indicates that during an experience where they were faced with moral dilemmas, they finally "felt a sudden insight into the socially-oriented view," (Kuhn, 1998). They had not had a strong grasp on what their professors had told them about ethics until faced with such experiences (Kuhn, 1998). Newberry agrees with the possibility that college-aged people are not yet ready to be involved in serious emotional engagement with ethical issues due to lack of personal experience and maturity (Newberry, 2004). He does, however, believe that it is necessary to "cultivate the soil" so that the knowledge and reasoning skills gained through an ethical education can later be employed in real life ethical dilemmas (Newberry, 2004). While ethical considerations may fully develop later on in an engineering career, it does not negate the need to educate engineering students in the field of ethics.

## Engineering ethics in education

### *History and importance of engineering ethics education*

In the past, the focus of class time in engineering and science course has been primarily on building students' technical competency, leaving it the students' responsibility to think of the ethical ramifications of their work (Bird, 2003). Recently, changes have been made so that ethics education is incorporated into engineering curricula. One significant motivation for

this change is revised Accreditation Board of Engineering and Technology (ABET) requirements in regards to ethics. Due to societal and professional trends towards ethical considerations within engineering, ABET wrote a section regarding ethics in *Engineering Criteria 2000* in 1995. While requiring no stand-alone ethics courses, ABET does state that "an understanding of the ethical, social, economic, and safety considerations in engineering practice is essential for a successful engineering career. Course work may be provided for this purpose, but as a minimum it should be the responsibility of the engineering faculty to infuse professional concepts into all engineering course work (Section IV.C.3.j)," (Lynch, 1998). Additionally, as stated in the 2009-2010 ABET criteria, engineering students should have "an understanding of professional and ethical responsibility," (Criteria for Accrediting Engineering Programs, 2008). From these criteria, it is apparent that ABET requirements demand that ethical concerns be addressed at some point in an engineering curriculum.

Another motivation for a focus on ethics in an engineering education can be attributed to politics surrounding technology such as nuclear weapons, environmental issues, and revised educational standards (Herkert, 2000). Through this, ethics education has been integrated into engineering curricula in the last quarter of the 20$^{th}$ century (Herkert, 2000). In fact, some trace its origin to the mid-1970s, at which time both professors in philosophy and engineering began to realize the importance of ethics in engineering (Lynch, 1998). It has been agreed that ethics education in an engineering curriculum should achieve "a) increased ethical sensitivity; b) increased knowledge of relevant standards of conduct; c) improved ethical judgment; and d) improved ethical will-power," (Herkert, 2000). To confirm this notion of a need for ethics education, Robert McGinn conducted a study in which it was

found that “80-90% of the practicing engineers surveyed thought that ‘current engineering students’ [were] likely to encounter significant ethical issues in their future engineering practice,” (Bird, 2003). Some even believe that in order to fully understand the social aspect of engineering, students should be exposed to an education with an emphasis on liberal arts (Williams, 2003). While this is a somewhat revolutionary idea, it is based on the idea that “a hybrid educational environment will prepare engineering students for handling technoscientific life in a hybrid world,” (Williams, 2003).

*Methods of effectively integrating ethics education into an engineering curriculum*

As has been established, the need for a solid foundation in terms of ethics education is necessary for a practicing engineer. Of course, as Kline states, “the question of how to educate engineers about the social implications and ethical issues of their work is a perplexing one,” (Kline, 2002). Newberry brings up important questions about engineering ethics education, including what students must know to be ethically and professionally responsible, how such knowledge can be imparted, and how an understanding of that knowledge can be measured (Newberry, 2004). Regardless of how to do these things, an “engineering ethics education that neglects the societal context of technological development will be found lacking,” (Herkert, 2000). Several sources have come up with a list of elements that are critical in an engineering ethics education. One source outline six such elements believed key to engineering ethics instruction. These include the professional engineering ethics codes, theoretical reasoning and moral theories, humanist readings, case studies, ethical heuristics, and service learning (Newberry, 2004). A wide variety of approaches to

and important aspects in engineering education should be considered in order to fully understand the current state of ethics education within the typical engineering curriculum.

Having stand-alone ethics courses, either offered within the engineering department or outside of it, is one method to educate engineers in the field of engineering ethics. This technique is not always successful, as the lack of integration of social considerations in courses can make it difficult for the students then to integrate them into their technical work (Kuhn, 1998). Similarly, Herkert holds that stand-alone courses may leave students with the impression that ethics is "a sidebar rather than integral part of their engineering studies," (Herkert, 2000). Stand-alone courses only reinforce the popular belief that ethical education is important only in addition to technical courses rather than being an intrinsic part of an engineering education (Chachra, 2005). Further, Kuhn suggests that stand-alone courses may even lead to a painful experience in the students' futures, as they possess an alternative view of engineering practice but are lacking the tools they need to address the problems that arise due to this alternate view (Kuhn, 1998). She believes that "freestanding ethics courses, especially those taught by faculty without an engineering background, face steep challenges in trying to influence the work practices of engineering students," (Kuhn, 1998). Those ethics courses taught within a philosophy department can cause trouble as they tend to rely on moral philosophy, which can cause students to ignore the "messy reality" of engineering practice (Kline, 2002). Not only lacking the ability to connect ethics to engineering practice, students bombarded with ethical theory may find frustration in their inability to find "right answers" to moral dilemmas (Lynch, 1998). While beneficial to provide students with an

ethical framework through stand-alone ethics courses, it is also necessary to provide them an understanding of how engineering decisions can be made within such a framework.

Integration of ethical concerns into technical coursework is a method that is agreed upon by many to be the most successful way to teach engineering students the importance of ethics in their careers. Addressing ethical issues in the context of technical education helps reinforce to the students that these issues will similarly be integrated into their day to day technical work in their careers (Chachra, 2005). Such issues could be integrated immediately in introduction to engineering courses, engineering science courses, discipline-based courses, and senior design courses (Herkert, 2000). It is possible to do this through a combination of integration projects, student initiatives, guest speakers, student competitions, presentations, conferences, panels, and discussion of real world cases (Cruz, 2003). Of course, resistance from engineering faculty and providing them with techniques to integrate ethics into their course material are two obstacles that would need to be overcome (Herkert, 2000). It has been suggested that this be accomplished through "ethical empowerment" of engineering faculty (Cruz, 2003). Ethical empowerment involves providing the faculty with ethical awareness, evaluative skills, preventative skills, integrative skills, and value realization skills through professional development workshops (Cruz, 2003). Basically, in order to properly integrate ethics into an engineering curriculum, faculty must have a social awareness founded in an understanding of ethical considerations and professional responsibilities within the field of engineering. The ability to integrate ethical concerns into other subjects in an engineering curriculum, like business and history classes, is beneficial as well, as it gives students a variety of perspectives when considering moral dilemmas (Cruz, 2003). Examining ethical

considerations throughout their engineering education with both a stand-alone course and integration through technical courses will impress upon students the inherent nature of ethics in the field of engineering.

A popular technique in engineering ethics education is the study of individual cases that have ethical considerations built into them. According to Davis, case studies work by "encouraging students to express ethical opinions, encouraging them to identify ethical issues and formulate and effectively justify decisions, and seeking 'to develop in students a sense of the practical context of ethics,' " (Herkert, 2000). Moral reasoning skills can be developed through case studies (Gorman, 2002). However, caution must be taken when ethical teaching is based on case studies, as the presentation of only disaster-based cases may cause students to believe that ethical considerations must only be made in emergency situations that will unlikely apply to them (Kline, 2002). The ethical analysis of various case studies can be valuable when acting as a compliment to other strategies of ethical education.

Knowing or memorizing engineering ethics codes is meaningless if the student doesn't know how to apply them (Gorman, 2002). In contrast to memorization, it has been proposed that a new method involving the history and sociology of science and technology be used to educate engineering students (Kline, 2002). Furthermore, some hold that while technical classes are essential to an engineering curriculum, liberal arts provide the foundation that can give engineers the perspective they need to be ethical agents in society. Kuhn believes that technical courses alone do not always create engineers who are capable of integrating technological and social demands (Kuhn, 1998). For example, little discussion is devoted to

human agents present in or affected by a technical process, and little mention is given to workplace or social impacts present in the design process (Kuhn, 1998). She mentions that even additional courses with more of a social focus do not necessarily give engineers the foundation that they need to successfully understand the importance of this integration (Kuhn, 1998). In agreement with this, Florman asserts that "the liberal arts are what fill out a person's education, helping turn narrowly focused professionals into discerning citizens, intelligent communicators, and potential leaders," (Harris, 2008). Harris notes that he believes that humanities and social sciences are "essential elements" in achieving both technical and non-technical engineering skills (Harris, 2008). Williams emphasizes that engineers must be prepared to work in a world in which technical, social, and humanistic issues mix (Williams, 2003). This preparation can take place within an education system where technological and liberal arts converge. Williams says that "students need to be educated in an environment where they get used to justifying and explaining their approach to solving problems and also to dealing with people who have other ways of defining and solving problems. Only a hybrid education environment will prepare engineering students for handling technoscientific life in a hybrid world," (Williams, 2003). Newberry sums it up nicely by stating that our goal should be "to get engineers to think in non-engineering ways, to have them grapple with issues that cannot be quantified or chartered," (Newberry, 2004). As indicated, incorporating liberal arts into an engineering curriculum is one way to educate engineers on the topic of ethics.

As mentioned, integrating ethical considerations into design projects is another technique to teach engineering students about the importance of ethics within the field of engineering. It is

appropriate to integrate lessons about ethics into design projects since by nature, engineering design involves the need to take multiple ethical constraints into consideration (Chachra, 2005). Similarly, the aspects that go into solving ethical problems are similar to those involved in solving technical problems (Davis, 1991; Whitbeck, 1998). Both require the problem to be defined, facts to be gathered, options to be developed, and resources to be evaluated (Davis, 1991). Spending time on these ethical concerns during design projects rather than glossing over them emphasizes to students the importance of identifying and giving attention to ethical considerations in a professional career (Chachra, 2005). Design projects often function to teach students how to integrate aspects of different engineering disciplines, and this can be extended to include lessons in how to integrate various social and political concerns as well (Kuhn, 1998). Whitbeck explains that by integrating ethics into design projects, engineering students are exposed to the multi-solution nature of ethical dilemmas (Whitbeck, 1996).

**Impact of local environment on students' ethical beliefs**

It has been suggested that it is not as much what the institution says but rather what the participants of the institution do in regards to ethics that influences the students' ethical understanding. It is believed that "what constitutes ethical behavior is very dependent on the local cultural environment," (Chachra, 2005). In the school environment, faculty act as models for the students, who derive many of their values from the examples they see (Chachra, 2005). Values reside not so much on specific information, but more so on underlying ethos in the environment (Newberry 2004). Newberry elaborates by saying that the focus in most engineering departments leans heavily towards highly technical ideas, often

leaving ethics courses and related ideas by the wayside (Newberry, 2004). In a study involving the analysis of engineering faculty publications in regards to societal and ethical context, it was found that very little attention was given to the subject of ethics (Newberry, 2004). Gunsalus provides several methods in which such an ethical environment can be created: the institution must support the importance of its members to "ask questions, obtain advice, and make ethically informed decisions," (Chachra, 2005). For example, whistleblowing is often a problem in engineering practice. By cultivating a "non-defensive internal culture" at the university level, students will learn that the presence of a problem does not take away from the integrity of the institution as a whole (Gunsalus, 1998).

The ethical local culture in an institution is even more important when considering that moral growth is thought to inherently be a "social phenomenon" (Lynch, 1998). Students depend both on each other and professors for ethical growth. As such, professor contribution to ethical courses is essential to a successful course. A professor's concealment of his or her ethical beliefs from a class can be detrimental to students' education (Lynch, 1998). According to Shue, "it creates a phony, distant relationship between the students and the teacher. It gives a false impression that all positions or all arguments are equal," (Lynch, 1998). Of course, good role models are important, but the behavior choices must be accompanied by an ethically-based explanation in order for students to fully benefit from example-based education (Bird, 2003).

**Social justice considerations in the field of engineering**

Some considerations that should be made during technology development and distribution are less obvious than others. For instance, engineers often have unknowingly ignored the uneven distribution of the products they create (Baillie, 2006). Technology is created with a certain consumer in mind, and often the diversity of the consumers in a country such as the United States is not accounted for. In this sense, technology can act as means to discriminate. Technologies have politics and values "associated with them and inextricably bound up within them," (Pritchard, 2006). It is important to incorporate ideas such as "social equity, justice, and sustainability" into an engineering education (Pritchard, 2006). Technology can be good, but the question remains, for whom is technological advancement good? (Baillie, 2006). This idea that the work of engineers can perpetuate the social injustice present in our country is noticeably absence from most papers discussing engineering ethics.

Another less obvious consideration is that engineering as a social and political institution can work to keep the powerful, privileged people in our country in those positions while simultaneously denying entry to everyone else. However, this notion that the nature of the field itself acts to perpetuate social injustice and systems of oppression and power in our country is virtually not mentioned.

Courses that address both engineering ethics and the social injustices often perpetuated by the field are few and far between. This research aims to understand the effects of a course focused on social justice and engineering ethics on bioengineering students at Oregon State University.

## Materials and Methods

Semi-structured interviews were conducted to gather data regarding student reaction to BIOE 420. Twenty bioengineering students and graduates from Oregon State University (OSU) in Corvallis, Oregon were selected based on the fact that they had all taken BIOE 420 within the last two academic years. These twenty were specifically selected based on their proximity to Corvallis, as all interviews were conducted on the OSU campus. Participants were initially contacted by email, with follow up by in-person contact. A copy of the contact material can be found in Appendix A.

Once students agreed to be interviewed, participants were provided with an informed consent document (see Appendix B) and time was allowed for participants to ask questions and receive clarification. Once participants had signed the informed consent documents, interviews were conducted in a quite and private room. Each participant was asked the same list of questions (see Appendix C). Questions revolved around topics such as the impact of the course upon the student's life, the aspects of the course that they connected with, the shaping of their moral views, the responsibility that an engineer has to social justice, and the value that they felt BIOE 420 had in comparison to another ethics course within their engineering curriculum. The only deviations to these questions were clarifying statements upon request by the participant. All interviews were audio recorded.

Following the interviews, the dialogues were transcribed and participants were allowed to review the transcription to ensure accuracy. Names were eliminated from the interviews upon transcription. Transcripts were analyzed to find common themes. These themes constituted

the basis of the results and discussion section. Demographic information for the interviewed students was compiled and reported (see Table 1, Appendix D). Of the twenty student interviewed, 40% were female and 60% were male. In terms of ethnicity, 70% of the students interviewed self-identified as white or Caucasian, while the remaining 30% self-identified as Vietnamese, Asian, Half-Japanese, Taiwanese, or chose not to respond to the question. Participants were between twenty-one and twenty-nine years of age, the majority being twenty-one or twenty-two.

One limitation to this study was small sample size. As students graduate and move across the world, it is hard to contact them for much longer than two years post graduation. For this reason, only students who took the course within the last two years were interviewed. Another limitation is that only one professor and one course were investigated. Optimally, engineering students who had taken a similar class from a different professor, or even at a different school, would also be included in this study. While the limitations inherent to this research prevent us from making generalizations to all engineering students, the study does provide valuable insight in regards to further research.

As the person most involved in the direct collection and analysis of data, I self-identify as a white, twenty-two year old female. I took BIOE 420 during the spring of 2008 and it greatly impacted my life. After being so affected by this course, I was interested to see if others were also transformed or changed due to the material covered.

## Results and Discussion

Most students interviewed thoroughly enjoyed and appreciated the BIOE 420 Social Ethics in Engineering course. One student said it was this course that gave him the courage "to stand up in a work setting and say this isn't right, and here's why." He also mentioned that while having taken philosophy courses before, it was BIOE 420 that "created the space for application," especially in an engineering setting. Another student said that "420 is one of the most valuable classes I've taken at OSU because it has stuck with me… ." She went on to mention that she loved coming to class, as it was "incredibly stimulating…really interesting and engaging." To sum it up, several students felt that "it would be nice if there were more classes" like this one because students would be less likely to forget the importance of the material presented. Evident through student response and praise, this course was well received and beneficial to the students who took it.

Throughout the interviews, student answers revolved around seven common themes:

- Most important lessons learned
- Importance of the course
- Moral development in relation to a social ethics course
- Promoting social justice
- Personal connection with the course
- A comparison of two ethics courses in the bioengineering curriculum
- Connection with firsthand experiences described in the course

Each theme will be discussed in the context of the course as a whole. Through this, it is possible to understand the effect of the course on the students who took it. Responses for each theme were also analyzed in terms of the sex, ethnicity, and the identification with marginalized communities of the interviewee. Apparent trends will be reported for each corresponding theme.

**Most important lessons learned**

While the overarching attitude toward the course was positive, the emotions and responses that the course elicited in students were varied. While the most important lesson that each student learned differed, several common lessons were mentioned by many students. These common lessons involved the appropriate treatment of others, the appropriate use of language, the ability to see a new perspective, and the understanding of systems of inequality.

*Treatment of others*

Many students mentioned the aspects of the course that highlighted the harmful treatment of others and the inequality that is ever-present in our society. One student said that the most important thing he learned was to "take the inequalities and think about them more often," rather than just noting their existence. Similarly, students pointed out that they gained a deeper understanding of the mistreatment of marginalized communities. As one student said, "anything you do, there are always consequences," so one should think about "who has to bear the burden of the negative side effects." Another student indicated that the most important thing he learned was to see people as people rather than a means to an end in the

workplace. Several students indicated that the most important lesson learned was to be aware of what others are going through. As indicated by these comments, students found it important to learn to consider the needs and emotions of humans both on a day to day basis and in a working environment.

Out of the eight students who indicated that they learned the importance of considering the appropriate treatment of others, seven were white. As 25% of the interview candidates self-identified as an ethnicity other than white, it would be statistically expected that 25% of the eight who talked about learning about treatment would also be of an ethnicity other than white. As this is not the case, it is possible that realizing the need to treat people differently was more of a revelation for white students than those who were not white. This is not surprising, as those students who were not white and therefore in a marginalized community likely have experienced unfair treatment and already understood the need to treat people fairly before taking this course. Also worthy to note is that all but one of the students who mentioned the need to treat others better identified with a marginalized community, where that identity did not stem from their ethnic group but rather from sex, sexual orientation, etc. Looking at the two trends together, it is possible that those who identify with a marginalized community based on ethnicity already practice equal treatment of others. Those who identify with a marginalized community in another way, then, may have emphatically related to the issues discussed in the class and were more easily able to understand the need to reevaluate how they treat others.

*Language use*

A large number of interview participants mentioned a reevaluation of the language they use on a day to day basis after taking this course. Students gained a deeper understanding of how certain terms reduce people "to one characteristic of themselves rather than taking them into account as a person." Regarding discriminatory terms, one student mentioned that she is more able to recognize how using such terms can stereotype "a gender or group of people." Other students indicated that they learned similar lessons regarding the power that language has in our society to both help and hurt people.

Having learned the effects that language can have on people, many students mentioned undergoing a conscious effort to change their language to eliminate offensive words and phrases. One student now tries to "make sure that [her] use of language is appropriate" by avoiding phrases that may be offensive to certain groups of people. Similarly, another student mentioned that the elimination of such offensive phrases changed her life in regards to how she uses language to interact with people. Many students mentioned that they have worked to correct their language and to consider how it may make other people feel. These decisions resulting in personal change signify that not only did students understand the lessons taught regarding the potential for language to be offensive and to be a contributing factor to the maintenance of systems of inequality, but they were willing to make a change in their personal lives in order to eliminate such language from their speech. While students found some behaviors that perpetuate inequality, such as disproportionate placement of waste, hard to change on an individual basis, it is important to note that they were willing to change one

tangible behavior in their lives. This willingness reflects a genuine care for the well-being of the marginalized communities discussed during the course.

*New perspective*

Because engineers are often not exposed to this type of material, students commented that they gained a new perspective. Understanding that we often go through our days focused on our own experiences, one student "appreciated…hearing perspective of other students." This course allowed her to step outside her own perspective and see "how others live their day to day lives." Another student saw her life from a new perspective, and gained an understanding that she was privileged. She said that she learned that since she is in a position of advantage, she should use it to help others. A student also learned to see situations from the perspective of the victim. She realized that she should not blame the victim in a situation, as she now understands that often, a much larger system is working against such victims than can be understood at first glance. Students both understood the need to take other people's perspectives and situations into account and appreciated the new perspective that the information in this course provided them.

Of the eleven students that mentioned acquiring a new perspective from taking this class, nine were white. These students all mentioned their ability to see systems of oppression from the perspective of the less privileged. The other two students who mentioned a new perspective were both women, one who self-identified as Vietnamese and the other as Asian. In contrast to the white students, both mentioned that they were able to see why they had been victims of discrimination over the course of their lives. While both those who identified

with the privilege group and those who identified with a marginalized community mentioned the acquirement of a new perspective, this perspective differed based on the student's personal experience.

*Systems of inequality*

Part of the course focused on the systems of inequality present in our society, which struck many students. One student noted that governmental power is "used against people…who are disadvantaged," and had her eyes opened when the course examined how government policy functions. She realized that while people think that the government is fair and ethical, sometimes it is not fair and ethical to everyone. As an example, she pointed to eminent domain being carried out by governments for the unstated purpose of "improving" the type of people living in certain neighborhoods. Another student became aware that inequality was "built into our culture and built into our social systems." She was struck by "how people don't even realize that [inequality] still exists and that a lot of it is completely subconscious." This realization made her "stop and reevaluate what [she] may or may not be doing subconsciously." Exposure to the inequalities built into our system of government in the US was particularly impacting for many of the students in this class. As indicated by their responses, many students expressed that they had not been aware of such systematic inequality beforehand.

As a part of the course, students watched a movie about the disparities that exist in the public school systems across the United States. From the movie, it was apparent that high poverty areas had very few resources for their public schools and students suffered because of it. The

movie showed schools with leaky ceilings in poor areas as compared to schools with university-level science equipment in more wealthy regions. One student mentioned that learning about this was a big part of the course for him, as people do not often think about it. Another confirmed this by saying that understanding the inequalities in the education system was particularly impacting, as this sort of stuff was never before "put in [his] face."

Out of the eleven students who better understood systems of inequality due to this course, four identified with a marginalized group based on ethnicity. This is statistically more than would be expected, and suggests that those who were in marginalized communities were suddenly more able to understand why they were treated in the ways they were. As a Vietnamese student said, "it made me see why I went through what I did." It seemed that while students knew they were being treated poorly, it was not until this class that they understood how systems of inequality perpetuate that treatment.

**Importance of the course**

Some engineers have expressed that ethical concerns are just common sense and that entire courses should not be devoted to understanding such issues further. Student responses during interviews suggested otherwise. Most students said that the course material was novel, but for those who had been previously aware of it, the course brought issues to the forefront of their minds. Students also indicated that the course provided a framework for beliefs they already held.

*Novelty of the course*

Students expressed that the material presented in this course was not covered in other formal coursework. A few said that they were not well prepared for the course prior to taking it. As one student said, no other classes helped him "prepare to critically think about those kinds of issues" and that "it was more like a first time in this class." Another said that "they don't teach us about any of this stuff" in other engineering courses. Perhaps due to the absence of ethical issues in engineering courses, another student mentioned that "people in engineering might be a little less inclined to have a good social education." Consistent with this, one student mentioned that it "really opened [her] eyes to oppression, issues of oppression that [she] never knew existed." In reference to discrimination, another student said "I didn't even recognize it as a problem."

In general, students felt that the material presented in this course was not a repeat from any other course, especially in the context of an engineering curriculum, but found it unique and valuable. Engineering students are usually not exposed to ethical views surrounding social justice issues in their technical coursework. Evident in the interviews, students recognized this and felt that the material was enlightening and new to them. Without this course, it is possible that many would leave college never having fully considered the systems of inequalities in our country and how they fit into such systems, both as a person and as an engineer.

*Revisiting of the issues discussed*

If students were aware of the material presented in this course from life experience or other education, they mentioned that this course was beneficial as it brought all of these issues to the forefront of their minds. One student said that "the things we covered in that class weren't even on the edge of my mind, a lot of it had been buried, and I would not have addressed things like that as critically without the class." He continued by saying that the most important thing he learned was how to bring those issues "from the back of the mind to the front, and whether you want to acknowledge them or not, they're there." Another student mentioned that before a course covering this type of material, students have not fully considered the implications of what happens in the world we live in. He felt that the good part of BIOE 420 was that "they try to bring it from the side [of your mind] and show you what's going on." He continued by saying that bringing the constructed societal norms to the forefront was incredibly important. A student that had been previously exposed to this type of material in a military setting said that while this course did not necessarily teach him new ideas, "it brings things to the forefront and maintains your awareness."

While some of the students were aware of these issues before, they all felt that this course helped reinforce the importance of keeping these ideas in the forefront of their minds. They did not view it as a waste of time or an unnecessary part of their education. Instead, they viewed it as an opportunity to revisit issues that they had often buried. Interestingly, all of the students who mentioned that this course helped them keep these issues in the forefront of their minds were white males. As these students are all members of the privileged group in society, it is understandable that issues surrounding privilege and power that primarily

positively impact them would fall to the back of their minds. It is also encouraging that they see the importance in avoiding that mindset and appreciate courses that bring awareness of inequalities back to the forefront.

*Structure for views already held*

A few students expressed that this course gave them a better understanding of views that they already held. One student recognized that this course reinforced her ethical views. She always knew they were there, but "this class brought them to light again." Similarly, another student said "I thought that it gave me a good structure to what I had been taught, growing up." She said that the lessons from her parents had no academic structure, but this course "made it more solid." These students provided evidence that this course reinforced previous ethical education, whether formal or informal. Rather than viewing the course as repetitive, they found it useful, as it enabled them to understand the formal and academic definitions behind their beliefs.

**Moral development in relation to a social ethics course**

People sometimes question if moral development continues after adolescence and if ethics courses can really impact older students, who are seen as having firm, static ethical and moral views. However, many believe that it is a process that continues throughout life and is especially impacted by education (Velasquez, 1987; Newberry, 2004). Student responses supported the latter hypothesis, as many indicated that educational experiences had somehow contributed to their ethical and moral views. Others indicated that ethical and moral views are not static, but ever-changing and based on life experience.

When asked what life experiences had shaped their ethical views, nine out of the twenty students interviewed indicated that they thought that either education shaped their views or that their ethical and moral beliefs change over time. One student talked about his ethical development from his high school years, and came to the conclusion that his "ethical and moral views now are shaped by [his] education." Some also mentioned that coming to college helped them accept other viewpoints and therefore shape their ethical views. Another student said that "taking this class certainly shaped my ethical point of view." These examples indicate that education and specifically, a course like this, can have a large impact on ethical development in students.

Several students mentioned that life experiences continually shape ethical views. One student expressed this by saying "I wasn't shaped before all of this, but I'm still being shaped. But I think that the experience of life shapes you, I don't think it stops." When asked what shaped his ethical views, another student said "probably college", indicating that his views were not set in adolescence. Reflecting the idea that ethical views are not stagnant, a student said "they've obviously changed" since childhood. One student provided an example of an educational experience that changed his views. When asked by philosophy professor if he was racist, he answered no. The professor then began to explain how world views have been engrained into people whether they know it or not. She explained that subconsciously, many of us are racist. In reference to this experience, the student said, "that's probably the biggest life experience I've had that has shaped my moral and ethical views." Apparent in their

responses, students believe that ethical and moral development is a process that never necessarily comes to completion.

The significance of this is that the moral and ethical views of these students are not unchangeable upon their entry to the course. Indicated by the interviews, students believe their views to be ever-changing and often influenced by educational experiences. Consequently, this course has the potential to produce engineers who are more socially conscious than they otherwise would be. After taking the courses, students are more likely to incorporate social justice concerns into their ethical beliefs.

**Promoting social justice**

As this course provided students with an understanding of social justice, students were asked how they plan to incorporate social justice into their work. Many students felt that they would incorporate social justice considerations not only in their jobs, but in their lives. Others gave specific reasons why engineers in particular need to consider such issues.

*Personal commitment to promoting social justice*

When asked if students felt that engineers had a responsibility to promote social justice, over half said that they did, but that this responsibility was not just unique to engineers. They believed all human beings have a responsibility to promote social justice. Ten students reflected ideas along the lines of the following comments, that they have the responsibility to promote social justice "more so just as a person, as someone in this world" and "just as a person who is aware of these things". Another said, "I think everyone has that responsibility,

I don't think anyone is exempt from it." Similarly, one student said "I wouldn't restrict it to engineers, I think that everybody has a responsibility…I don't see it as an engineering issue, I see it as a global issue."

Two students made a distinct connection that they are people who happen to be engineers, and must carry their personal responsibilities into engineering: one said that "as a person, I think I have the responsibility to promote social justice and because I am a person that is an engineer, I must also do it in engineering" and the other said "engineers have the same responsibility as anyone, and being an engineer doesn't really set you apart." The number of students who indicated that promoting social justice is a human responsibility is evidence that this course showed students the value of considering these issues in their day to day lives. Several students understood that their day to day lives will involve working in an engineering field, in which they also must promote social justice.

Out of the twenty students interviewed, thirteen indicated a commitment to promoting social justice in their personal lives. These thirteen students included both those who did and did not identify with a marginalized community. While previous demographic analysis of common themes has shown that those who do identify with a marginalized community seem to be express more of a desire to make specific change, this trend does not seem to apply to the general goal of promoting social justice. Students who do not identify with a marginalized community may not have an inside perspective that provides them with the best specific methods for change, but results show that this does not mean that they are unwilling to promote change.

*Promoting social justice through an engineering career*

Students mentioned that engineers have a particular responsibility to promote social justice due to the nature of the field. First of all, several mentioned that in the field of engineering, innovations are being produced for the general public. As such, one student mentioned that "how [engineers] use technology should really be evaluated." Another observed that engineers have power because of the things they design. Secondly, given the idea that engineers have the potential to use their innovations to help people, students talked about the need for socially just decisions based on this potential. According to one student, "all engineers have…the privilege to help a lot of people." Based on their work, they have "the possibility of affecting people's lives or making their lives better, so I think that as engineers, we should be very aware of the social impact that we might have." Another pointed out that engineers "can impact so many lives in a good way or in a negative way." This course made one student "aware of the fact that [she has] this knowledge and the power to change things and better the lives of individuals." Because of this, she felt that she should "evaluate who is impacted by [technology]" in order to make just decisions. Another student mentioned that engineers have "an impact on social equality or an impact on communities and different people, just depending on the choices they make." On the topic of choices, one said that engineers should "try to be very thoughtful of the decisions [they] make and do one that's going to be the more socially just choice."

Many students noted that engineering products can be intrinsically discriminatory. One student noted that with the ability to "make a difference and actually create new products"

comes the need to “take into consideration” social justice. She continued to say that engineers typically make things that are needed by the population that [the engineers] most closely identify with. For this reason, it is “good to introduce a new perspective…and promote social justice.” Another student echoed this as he said that “the things we design need to be for the people and it can’t be for some people. If we’re going to design new technologies or new drugs, we have to consider the implications.” As an example of this, he mentioned that drug development targets diseases that “exist in poor or underrepresented communities, but then they don’t have access to it” due to high cost. Similarly, one student learned that it is important to keep the “financial cost” in mind when “they develop a product.” Also, “they should keep in mind that the different classes have different needs, different genders have different needs, so they should try to address those equally.” Because “engineers work for the benefit of society…it is important to take into account the consumers, the individuals that we are doing this for. So as an engineer, it shouldn’t matter to me where my client was born or who they are attracted to or anything like that.” These comments all show that from this course, students gained an understanding of how technology can discriminate. They also indicated an understanding that to avoid such discrimination, they should make products that are accessible to all people.

The large number of students who connected personally with promoting social justice suggests that students feel personally responsible for integrating the promotion of social justice both in their lives and in their careers. Students gave examples of situations in which social justice can be overlooked, which indicated that BIOE 420 provided them with the critical thinking skills necessary to identify injustice. Following that, the course also provided

them with the understanding that they have a responsibility to make just decisions. As such, it is important that they have a strong foundation from which to make such choices. It seems that this course gave them that, as students mentioned the need to be aware, thoughtful, and evaluative of the potential for engineering decisions to perpetuate injustice in marginalized communities. Like one student said, “for engineers to be whole people and to be the best engineers they can be, they have to have these considerations.”

*Promoting social justice within the engineering community*

Engineers have many responsibilities in the workplace, many of which involve an awareness and understanding of difference and diversity. Engineers must be able to communicate effectively with the people around them on a daily basis (Kuhn, 1998; Gorman, 2002). Student responses reflected an understanding of this aspect of an engineer’s work. One student mentioned that “when you are in a professional atmosphere, you should just…be very nonjudgmental and use neutral words instead of having things that are weighted or could be offensive.” Another student said that she felt that with the views gained from this course, she would “evaluate what company” she wanted to work for, as she would now think harder about working for a company who did not keep the best interest of those who it serves in mind. Two students also indicated that this course showed them the importance of making good and fair decisions when hiring. In an academic working environment, one student indicated that she “would like to try to promote the acceptance of different types of people.” Having the bioengineering professors at OSU that are “accepting of students of different types” and each other has provided her with an example of how she would like to do this in her future.

These results are important because the engineering field is often very exclusive to everyone except the dominant paradigm: white, middle-class males. By making the field more inclusive of communities of people that are currently underrepresented in engineering, it is possible that the field as a whole would make decisions that positively impacted such communities. Students reflected the desire to incorporate this inclusiveness in the workplace.

**Personal connection with the course**

It was hypothesized that the students who identified as part of a marginalized community or were close to someone from a marginalized community would most strongly connect with this course. As women are a marginalized group not only within the engineering community but in the world, the trends between student and level of connection was analyzed for the female students and then the male students. Once divided by sex, students were further categorized based on age, ethnicity, and other characteristics that may have caused them to identify with a marginalized community. It was then determined if the course impacted the student based on evidence from the interviews.

Of the females interviewed, five out of eight experienced a connection with the material presented in this course. Of the males interviewed, six out of twelve experienced a connection with the material in this course. Of those six, all were either in a marginalized community or close to people who were in a marginalized community. The males who did not indicate any connection to the course did not mention personal identification with a marginalized community. These trends support the hypothesis that students who were members of or knew members of a marginalized community connected more strongly with

the course. Students mentioned that as members of the privileged class, they found it hard to connect to the stories of people who were victims of the systems of inequalities present in our country. From the data provided, it is evident that students who had experienced being victimized or seeing those close to them victimized due to involuntary placement within a marginalized community connected most strongly with the stories, essays, and movies shown in class. It is important to note, however, that a lack of connection with the course did not mean that the students found the course to lack value or lack impact, but just that they simply could not personally relate to the scenarios described in course.

**A comparison of two ethics courses in the bioengineering curriculum**

The bioengineering curriculum as OSU requires that students take two ethics courses: BIOE 320, which gives students an introduction to engineering ethics, and the course discussed here, BIOE 420, which focuses on social justice in the context of engineering. BIOE 320 focuses on such topics as ethical theory, professional engineering responsibility, codes of ethics, ethical assessment, conflicts of interest, risk and safety, loyalty, and other overarching professional concerns. Students were asked to reflect upon which course they found to be most valuable. Out of the twenty students interviewed, ten said that both courses had equal value, nine said that BIOE 420 was more valuable and one said that BIOE 320 was more valuable. Several students felt that BIOE 320 was purely theoretical and did not give them the ability to apply the concepts learned. Others thought that BIOE 320 provided an ethical foundation and framework that they used in BIOE 420.

Furthermore, when asked if all engineers should be required to take BIOE 420, nineteen out of twenty responded by saying yes. They mentioned that “it’s an important class for all engineering majors to take,” and that it consisted of material that “all engineers should be thinking about.” One student went as far to say that she felt “kind of bad that other engineers are missing out” by not taking the course. Of those nineteen who felt that all engineers should take this course, nine said that not only engineers should take this course, but all people. One student explained that “anybody in a position to impact people on a broad social level” should be required to take this course and another said that “everyone at OSU should take that class.”

Student responses showed an agreement that each course covered a different aspect of engineering ethics. While some overlap between the courses existed, the two aspects that were generally unique to each course were microethics and macroethics. As defined by Herkert, microethics are “concerned with individuals and the internal relations of the engineering profession,” while macroethics refer to “the collective social responsibility of the engineering profession and to societal decisions about technology,” (Herkert, 2001). According to this definition, BIOE 320 covers more issues surrounding microethics while the material in BIOE 420 is more focused on macroethics. It is important to note that students found the macroethics material, generally not taught within an engineering curriculum, to be at least as valuable if not more valuable than microethics material. Not only that, but students felt that other engineers and even all people should be required to take this kind of course. Student response indicated that the macroethic considerations are important both for their personal lives and their professional lives. While the value of such a course is questioned by

some, the bioengineers at OSU provided evidence that BIOE 420, a course focused on social justice (a macroethics topic in engineering), was informative, useful, and sometimes even life-changing.

**Connection with firsthand experiences described in the course**

Students expressed that hearing about firsthand experience from people in marginalized communities made the course real for them. They indicated that they enjoyed hearing both from panels and the professor. Further, students expressed a desire to put the ideas they learned into practice in order to solidify the experience.

*Connection with panels consisting of members of marginalized communities*

Many students indicated that one of the most valuable parts of the course involved understanding more about the experiences of members in marginalized communities. One part of the course involved a panel of such members talking about their experiences. One student said that he liked when "we had panels of people who came in, and they talked about their experiences," as it "made it real" for him. "The panel stands out in my mind," said another student. "It actually puts some reality to it…I think that is a really solidifying point of the class." Still another said that "hearing from the people firsthand that have been affected by this the most, rather than just being told what it's like for them…is more impacting." As indicated by these students, who perhaps had little experience with marginalized communities in the past, learning about the experiences of those from such communities was beneficial. The students could actually see that the concepts learned in class happened in the outside world. Humans tend to feel empathy towards other humans

undergoing hardships. Listening to a panel of people and putting a face to the hardships discussed in class seemed to lead students to feel a connection with these people, possibly giving them the desire to fight social inequalities.

*Connection with the professor's transparency*

The professor of BIOE 420 also revealed a lot about her own personality and life. Students appreciated this aspect of the course. According to one student, this allowed students to "get close to the material and it can become real, and it can become something that's not…just at theoretical mental thing." Similarly, another said that when the professor "opened up to the class about specific details about herself…it made the class more real" to him. This reflects that students were impacted by the professor's ability to open up about her own experiences in the social systems of oppression described in the course. Similar to the panels, hearing firsthand experience from the professor helped the material become more real for students.

*Desire for firsthand experience*

A common theme that ran throughout the interviews was the desire for more praxis, or putting the material presented in class into action. One student wished that she had "learned more about how to deal with those situations…more like a strategy." Similarly, another expressed the desire "to learn a little bit more about things that [she] can do and to play a role in trying to start a change." The only improvement to the course that one student could think of was to provide students with "more information about how to be proactive." Some students had ideas about how this could be achieved. One said that the only way the course would have impacted him more is to have "more hands on sort of assignments, where you go

and volunteer at a soup kitchen…or something like that." Along the same lines, another thought that a "community project would have been helpful." The three students who mentioned specific examples like this were all white, possibly indicating that in order for them to better grasp the material, they would appreciate the opportunity to interact with people who it affects firsthand.

Often characteristic to engineers, who tend to be inclined towards problem solving, students wanted to have more information regarding how to be proactive in fighting against some of the inequalities discussed. Many engineers thrive in situations where they have the tools and skills necessary to solve a problem. In this case, the students desired strategies and concrete ways to take action against the problems presented in class. Some students felt that going out into the community would provide them with a deeper insight and understanding of the material presented based on a first hand experience. Overall, the desire to learn more and get more first hand experience indicates that the students were personally affected by the material presented in class and motivated to right some of the wrongs presented. From this, it is apparent that the course brought to light issues that the students had not thought about before but found important enough to learn more about.

## Conclusion and Course Recommendations

The interviews conducted indicated that students found BIOE 420 enlightening, informative, and a valuable part of their engineering education. Some had good ideas about how the course could be changed in the future. One student wished that the material presented could have been more integrated into "real world engineering application." He felt that rather than spending the first half of the course understanding the systems of inequalities present in society and the last half apply this to engineering, the learning and application should happen in closer proximity to each other. As many students expressed, more exposure to real life situations would be beneficial as well. One thought that "exposing people to more real world situations….may have impacted the whole class a little more." Students wanted to be able to see social injustice firsthand by working in a soup kitchen or a homeless shelter. Another saw benefit in opening the course to "not just engineers" in order to "have more diversity." Lastly, a student wished the course would have taken more current events into account. These suggestions could all be integrated into BIOE 420 in the future to improve the impact that the course has on students.

In the future, it is also possible to teach how other ideologies used to solve engineering-based problems can be applied to issues surrounding social justice. For example, Woodhouse makes an interesting argument in a paper regarding engineering responsibility toward curbing overconsumption. He states that "Engineers as individuals are not the main cause of overconsumption, and therefore cannot be the main solution. Engineers work within a web of constraints created by employers, consumer tastes, government policy, and other social forces," (Woodhouse, 2001). Towards this end, he proposed that engineers should 1)

stimulate conversation within engineering and more generally; 2) focus on optional ethical behavior; 3) expect organizations like schools to take the lead, not individuals; and 4) think of how engineers can act responsibly not only on the job, but as citizens and consumers (Woodhouse, 2001). It seems plausible that a similar path towards intervention could be developed to address engineering responsibilities as they relate to problems of social justice. In the present study, it is apparent that students desire knowledge about how to change the systems of inequalities that are so prevalent in our society. Teaching an adapted version of Woodhouse's approach to curbing overconsumption as a strategy to deal with these systems that engineers work within could be beneficial. Students would see that engineers are not the only ones to blame and would be provided with tangible ideas regarding how to fight some of these social justice issues.

The overall reaction to BIOE 420 from the students interviewed was quite positive. Students seemed to take away important lessons and apply them to their own lives when possible. They understood how the ideas surrounding social injustice presented throughout the course were connected to engineering. By taking a course focused on issues surrounding social systems of oppression and their relation to engineering, students are more prepared to work as engineers in our society.

Further research would first involve a larger sample size. As students take this class in the following years, they could also be interviewed. In addition, these students would be asked questions regarding their reaction toward any changes in the course based on the recommendations made by students in this study. It would also be interesting to seek out

other social ethics courses specific to certain majors and interview students of those courses. By doing this, it would be possible to see which aspects of these courses were common and which were best for student learning. As a long term study, it would be interesting to interview these students after they had worked in an engineering career for a few years in order to see if this course had at all impacted decisions in their careers.

# Bibliography


Baillie, C. 2006. Engineers within a Local and Global Society. Morgan and Claypool Publishers.

Bird, S. 2003. Ethics as a Core Competency in Science and Engineering. *Science and Engineering Ethics* 9: 434-444.

Bothwell, M.K. and McGuire, J. 2007. Difference, Power and Discrimination in Engineering Education. *In Teaching for Change*, ed. Xing J., Li J., Roper L., and Shaw S. Maryland: Lexington Books.

Chachra, D. 2005. Beyond Course-Based Engineering Ethics Instruction: Commentary on "Topics and Cases for Online Education in Engineering" (J. Smith). *Science and Engineering Ethics* 11: 459-461.

Children's Mental Health. 2009. Retrieved on April 29, 2009 from the National Center for Children in Poverty Web Site: http://www.nccp.org/topics/mentalhealth.html.

Criteria for Accrediting Engineering Programs. 2008. Retrieved on April 29, 2009 from the ABET Web site: http://www.abet.org/forms.shtml#For_Engineering_Programs_Only.

Cruz, J.A. and Frey, W.J. 2003. An Effective Strategy for Integrating Ethics Across the Curriculum in Engineering: An ABET 2000 Challenge. *Science and Engineering Ethics* 9: 543-568.

Davis, M. 1991. Thinking Like an Engineer: The Place of a Code of Ethics in the Practice of a Profession. *Philosophy of Public Affairs* 20: 150-167.

Gorman, M.E. 2002. Turning Students into Ethical Professionals. *IEEE Technology and Society Magazine* Winter 2001/2002: 21-27.

Gunsalus, C.K. 1998. Preventing the Need for Whistleblowing: Practical Advise for University Administrators. *Science and Engineering Ethics* 4: 75-94.

Harris, C.E. 2008. The Good Engineer: Giving Virtue its Due in Engineering Ethics. *Science and Engineering Ethics* 14: 153-164.

Herkert, J.R. 2000. Engineering Ethics Education in the USA: Content, Pedagogy, and Curriculum. *European Journal of Engineering Education* 25: 303-313.

Herkert, J.R. 2001. Future Directions in Engineering Ethics Research: Microethics, Macroethics and the Role of Professional Societies. *Science and Engineering Ethics* 7: 403-414.

Johnson, A.G. 2006. *Privilege, Power, and Difference*. 2nd Edition. New York: The McGraw-Hill Companies, Inc.

Kline, RR. 2002. Using History and Sociology to Teach Engineering Ethics. *IEEE Technology and Society Magazine* Winter 2001/2002: 13-20.

Kuhn, S. 1998. When Worlds Collide: Engineering Students Encounter Aspects of Production. *Science and Engineering Ethics* 4: 457-472.

Lynch, W.T. 1998. Teaching Engineering Ethics in the United States. *IEEE Technology and Society Magazine* Winter 1997/1998: 27-36.

Newberry, B. 2004. The Dilemma of Ethics in Engineering Education. *Science and Engineering Ethcis* 10: 343-351.

Pritchard, J. and Baillie, C. 2006. How can Engineering Education Contribute to a Sustainable Future? *European Journal of Engineering Education* 5: 555-565.

U.S. Public Health Service Syphilis Study at Tuskegee. 2009. Retrieved on April 29, 2009 from The Center for Disease Control Web Site: http://www.cdc.gov/tuskegee/timeline.htm.

Velasquez, M., Andre C., Shanks, T., J., S., and Meyer, M. J. 1987. Can Ethics Be Taught? Retrieved on April 29, 2009 from the Markkula Center for Applied Ethics on the Santa Clara University Web Site: http://www.scu.edu/ethics/practicing/decision/canethicsbetaught.html.

Whitbeck, C. 1996. Ethics as Design. *Hastings Center Report* 26: 9-16.

Whitbeck, C. 1998. Ethics in Engineering Practice and Research. New York: Cambridge University Press.

Williams, R. 2003. Education for the Profession Formerly Known as Engineering. *Chronicle of Higher Education*. 49: B12

Woodhouse, E.J. 2001. Curbing Overconsumption: Challenge for Ethically Responsible Engineering. *IEEE Technology and Society Magazine*. Fall 2001: 23-30.

# APPENDICES

# Appendix A

**Contact Email**

Dear Engineering Student,

My name is Torri Rinker, a senior in bioengineering at Oregon State University. Most of you know me from your classes or from my participation in CBEE club. For my Honors College thesis, I am conducting interviews regarding BIOE 420 Social Ethics in Engineering. Because you have completed this course, I am writing to invite you to participate in my thesis research.

The purpose of this research is to understand the impact that a social ethics class in the engineering curriculum has on bioengineering students. I hope to correlate the impact that it has on each individual student to the moral views that he or she holds and the past ethics education that he or she has had. The resulting data will be used in my thesis and possibly a journal article, as well as in shaping the social ethics class in the future.

To conduct this research, I will be conducting personal interviews of students who have taken this class in the last two years. The interview questions will ask about your reaction to the class, your view on ethics in engineering, and other similar questions. As the bioengineering program is fairly small, I hope to interview most of the students who took the class spring 2007 and 2008 so that I can compile enough data to draw correlations. If you choose to participate, I will schedule a 30-60 minute interview with you at your convenience. If you agree to this interview, it will be audio recorded and then transcribed. Your name will be eliminated as soon as the interview has been transcribed. I will share a transcript with you to ensure completeness and accuracy.
If you are interested in participating in this study, please reply to this email and I will contact you shortly to set up an appointment. If you have questions, please feel free to contact me at the phone number or email address provided below.

If you are not interested in participating in this study, please let me know.

Thank you for your time and I look forward to speaking with you!

Torri Rinker
rinkerto@onid.orst.edu
509-947-5075

# Appendix B

**Informed Consent Document**

Project Title: **The Impact of an Ethics Class on Views Held by Bioengineering Students Regarding Social Justice Issues**
Principal Investigator: **Michelle Bothwell, CBEE Department**
Investigator(s): **Torri Rinker, CBEE Department**

## WHAT IS THE PURPOSE OF THIS STUDY?

You are being invited to take part in a research study designed to understand the impact of the class BIOE 420 Social Ethics in Engineering on bioengineering students. We hypothesize that correlations between the impact of the class on each student and their moral views and past ethical educational experience exist and we hope to more fully understand these trends. From this research, we anticipate writing a thesis for the OSU Honors College and possibly publishing a journal article in an engineering education or ethics journal. We are studying this because we have noticed that many engineering students at OSU seem apprehensive about taking ethics classes, viewing them as a waste of time and irrelevant to their career. Not all engineers feel this way, however, and this research will be conducted to determine if a social ethics class offered in an engineering student's department of study can change his or her views on the importance of ethics in an engineering career.

## WHAT IS THE PURPOSE OF THIS FORM?

This consent form gives you the information you will need to help you decide whether to be in the study or not. Please read the form carefully. You may ask any questions about the research, the possible risks and benefits, your rights as a volunteer, and anything else that is not clear. When all of your questions have been answered, you can decide if you want to be in this study or not.

## WHY AM I BEING INVITED TO TAKE PART IN THIS STUDY?

You are being invited to take part in this study because you are a bioengineering student who has completed BIOE 420 Social Ethics in Engineering class and lives in Corvallis.

## WHAT WILL HAPPEN DURING THIS STUDY AND HOW LONG WILL IT TAKE?

We will be conducting personal interviews of students who have taken this class in the last two years. The interview questions will ask about your reaction to the class, your view on ethics in engineering, and other similar questions. If you agree to participate, we will interview you for 30-60 minutes. The interview will be audio recorded and then transcribed. We will share a transcript with you to ensure completeness and accuracy. The interview will take place in a private location agreed upon by you. If you agree to take part in this study, your involvement will last for 30 to 60 minutes.

## WHAT ARE THE RISKS OF THIS STUDY?

The possible risks and/or discomforts associated with the procedures described in this study include:
-Embarrassment/discomfort when answering personal questions about ethical beliefs. To eliminate this risk, you can refrain from answering a question or end the interview at any time.
-Embarrassment/discomfort about Professor Bothwell hearing your answers to the interview questions. To eliminate this risk, only Torri will be present during the interview process and names will be eliminated before Professor Bothwell sees the interview results.

## WHAT ARE THE BENEFITS OF THIS STUDY?

We do not know if you will benefit from being in this study. However, we hope that, in the future, other people might benefit from this study because they will gain a deeper understanding of the impact and need of a social ethics class in the engineering curriculum. If ethics classes are implemented in other engineering curriculum, this will not only benefit the engineers receiving the education, but also the people they will serve in their future careers.

## WILL I BE PAID FOR PARTICIPATING?

You will not be paid for being in this research study, but you will receive a gift certificate for MU Retail Food Services.

## WHO WILL SEE THE INFORMATION I GIVE?

The information you provide during this research study will be kept confidential to the extent permitted by law. To help protect your confidentiality, we will assign each participant a number in place of their name and keep all documents on Torri's personal laptop, which is kept locked in her house or with her at all times.

One aspect of this study involves making audio recordings of you. These will be made so that Torri can transcribe the interview after it takes place. Recordings will be stored on Torri's personal laptop, which is kept locked in her house or with her at all times. These recordings with be destroyed once a transcription is made, eliminating your name from stored records.

If the results of this project are published your identity will not be made public.

## DO I HAVE A CHOICE TO BE IN THE STUDY?

If you decide to take part in the study, it should be because you really want to volunteer. You will not lose any benefits or rights you would normally have if you choose not to volunteer. You can stop at any time during the study and still keep the benefits and rights you had before volunteering. If you decide not to take part in this study, your decision will have no effect on your relationship with Professor Bothwell or Torri.

You will not be treated differently if you decide to stop taking part in the study. Participants can refrain from answering a question or end the interview at any time. If you choose to withdraw from this project before it ends, the researchers may keep information collected from you and this information may be included in study reports.

**WHAT IF I HAVE QUESTIONS?**

If you have any questions about this research project, please contact: Michelle Bothwell, bothwell@engr.orst.edu, (541) 737-6313, or Torri Rinker, rinkerto@onid.orst.edu, (509) 947-5075.

If you have questions about your rights as a participant, please contact the Oregon State University Institutional Review Board (IRB) Human Protections Administrator, at (541) 737-4933 or by email at IRB@oregonstate.edu.

---

Your signature indicates that this research study has been explained to you, that your questions have been answered, and that you agree to take part in this study. You will receive a copy of this form.

Participant's Name (printed):

_____

_____

(Signature of Participant) (Date)

# Appendix C

**Interview Materials**

*Demographic Survey (Optional)*

Sex:
Ethnicity:
Age:
State in which you grew up:
Sexual identity:

*Interview Questions*

1. Up to the point of taking BioE 420, had you taken a class focused on topics such as privilege, power, gender and race before? Was this a DPD course?
   1.1. If yes, how did that class impact your life?
2. How did BioE 420 impact your life? How did it compare to your DPD class?
3. Specifically, which aspect of BioE 420 impacted you the most?
4. Was there a moment in this class that stood out to you? Please describe.
5. How did you connect personally with this class?
6. How could this class have been different so that it would have impacted you more?
7. What life experiences have shaped your ethical and moral views?
8. How do you define social justice? Did this class help you construct this definition?
9. As an engineer, do you think you have a responsibility to promote social justice? If so, how do you plan to do this in your career?
10. Do you feel that your education prior to taking BioE 420 prepared you to interpret and critically think about essays, articles, and movies focused on issues surrounding privilege, power, gender, and race?
11. What is the most important thing you learned from this class? What do you wish you would have learned?
12. Do you think that everyone had a similar experience in this class? Explain.
13. Did you find yourself in agreement with the material presented in this class?
14. Do you think this class is valuable? Why or why not? Do you think it is more valuable than the first ethics course we took, BioE 320 Professionalism and Engineering Ethics? Do you think that BioE 320 prepared you for this class?
15. Were you apprehensive about taking this class?
16. Do you think that all engineers should take this kind of class?

# Appendix D

## Demographic Information

**Table 1.** Demographic information of students interviewed. Sex, age, and ethnicity were provided by the students. Characteristics that would cause students to identify with a marginalized community were determined from interviews.

| Sex | Age | Ethnicity | Characteristic that would cause students to identify with a marginalized community |
|---|---|---|---|
| Female | 24 | White | Sex |
| | 22 | White | Sex |
| | 21 | Caucasian | Sex, once overweight |
| | 22 | White/ Caucasian | Sex |
| | 22 | White | Sex, sexual identity-“bi/queer” |
| | 21 | White | Sex |
| | 22 | Vietnamese | Sex, ethnicity |
| | 22 | Asian | Sex, ethnicity |
| Male | 21 | Not provided | None evident |
| | 22 | Half Japanese | Ethnicity |
| | 23 | Caucasian | Sexual Identity-“queer” |
| | 29 | Caucasian | Mother with a disability, lived in poverty |
| | 28 | Caucasian | Perspective from a military background |
| | 21 | Asian | Disabled |
| | 23 | Caucasian | Association with gay friends |
| | 22 | White | None evident |
| | 21 | White | None evident |
| | 27 | White | None evident |
| | 27 | Taiwanese | Ethnicity |
| | 23 | White | None evident |