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Dr. A. Dean Fontenot, Texas Tech University

A. Dean Fontenot directs a professional development center for K-12 teachers as part of the Texas STEM (T-STEM) initiative in order to bring about educational reform in secondary schools. The Texas Tech T-STEM Center focuses on project-based learning with the integration of the engineering design process. As Senior Director, she has brought together three Texas Tech professional development centers that have a history of training teachers, and built partnerships with five Educational Service centers as well as other organizational and industry partners who help implement the professional development training. The Center provides professional development training for 46 T-STEM Academies, five T-STEM Early College High Schools, and all Texas school districts, public and private. She collaborates with Whitacre College of Engineering Faculty, as well as faculty from other universities writing grant proposals. Over 10 years, Fontenot has secured more than $3.8 million for STEM education ($3,133,000 of this in the last five years). Fontenot teachers Professional Communications for Engineers: practical applications to written, oral, and internet communications, as well as an introduction to engineering ethics and service learning (2001-current).

Mr. Richard A. Burgess, National Institute for Engineering Ethics

Richard Burgess currently works as a Research Associate and Deputy Director at the Murdough Center for Engineering Professionalism (MCEP) and National Institute for Engineering Ethics (NIEE) at Texas Tech University. He oversees the day to day operations of the center's distance learning courses for both engineering students and practicing engineers. Additionally, he provides lectures on ethical theory and other topics in an on-campus engineering ethics course. Burgess was also a member of the Ethics in the Curriculum Task Force for Texas Tech's Quality Enhancement Plan. The Quality Enhancement Plan was a crucial component of Texas Tech's accreditation with the Southern Association of Colleges and Schools. A theme throughout these roles is the importance of teaching ethics and promoting ethical reflection in a way that is both accessible and substantive. This is a challenge that Richard is keenly interested in. He holds bachelor's and master's degree in philosophy. He placed an emphasis on ethics, both theoretical and applied, in his studies.

Ethical Issues Awareness for Engineers in Practice

As a discipline, engineering ethics is a relatively young one. Younger still is the question of how to teach engineering ethics. Like other applied disciplines, the challenge of engineering ethics is to offer content that is both useful to practitioners and genuinely substantive (i.e. moves beyond glossy generalizations about the importance of honesty, non-malfeasance, etc.). Additionally, engineering ethics education, it is hoped, will make students 1) less likely to engage in academic dishonesty 2) more likely to succeed on the ethics portion of the F.E. and 3) more aware of the obligations and issues they are likely to face in engineering practice. While each of these additional desiderata is important, the last is arguably the most important. It can also be the most pedagogically challenging.

In this paper, we will explore the challenges posed by the third goal above in the context of an assignment used in both an engineering communications course and an engineering ethics course at a research institution. In this assignment, the Social Impact Analysis (SIA), students are asked to identify and research a current engineering design, product, or concept that is (or soon will be) impacting society. Prima facie, this assignment promises to help acquaint students with the complexity of deploying new technology in society (domestically or globally). The actual and potential impacts of these technologies raise a host of ethical issues that are students must be aware of and engage. However, as analyses and discussions become more nuanced (in light of complexity), they can also become more abstract and, therefore, less practically important to students. If not handled properly, an assignment like the SIA can be viewed as an exercise in intellectual curiosity and little more. Worse still, it may actually lead to exasperation with attempts to carefully explore ethical obligations in engineering. To be most effective, then, the SIA requires the right setup.

We will explore several iterations of the SIA based on different contexts (e.g. use in an engineering writing/communications course, use in an engineering ethics course, and use as a stand-alone assignment). We will enumerate what we take to be reasonable goals for the SIA given these contexts. These goals will determine how the assignment is to be completed and evaluated. Finally, we will explore the use of the SIA in a K-12 setting. Despite the potential complexity the SIA can lead to, it may be *most* effective when used in K-12 STEM education.

Introduction

Educators teaching engineering ethics are often faced with three distinct, hoped for outcomes. First outcome – it is hoped that the inclusion of engineering ethics in the curriculum will better prepare students for the ethics portion of the Fundamentals Exam (F.E.) than they otherwise would have been. This outcome is the most tangible and limited of the three. Second outcome – it is hoped that students exposed to engineering ethics will be less likely to engage in academic dishonesty. This is an understandable hope given that academic dishonesty in engineering is at

least as prevalent as any other academic discipline. Third outcome – it is expected that studying engineering ethics (in some form) will acquaint students with the obligations they will have as engineers and familiarize them with sources of guidance (e.g. engineering codes of ethics). While, in principle, these outcomes are not mutually exclusive, they do require different pedagogical approaches. For our part, we believe the third outcome is the most important. It is, however, also the most difficult to achieve. This paper will address how a particular assignment, the Social Impact Analysis (SIA), fits into engineering ethics education in this third sense.

Whether teaching engineering ethics, biomedical ethics, business ethics, etc., there have been, traditionally, *three overarching goals* associated with the undertaking. First, students should walk away with an enhanced level of ethical sensitivity. That is, students should be able to identify ethical issues/challenges they would have otherwise overlooked. This is not about manufacturing issues where there are not any; something philosophers are sometimes accused of doing. Rather, it is about recognizing issues in situations previously thought amoral and/or seeing existing ethical situations in a more nuanced manner. Second, students' ethical reasoning should be stronger as a result of studying ethics. Measuring improvements in reasoning has been a challenging endeavor. Nevertheless, we are not at a complete loss for objective standards of improvement. An increased knowledge of opposing points of view and ability to anticipate and respond to criticisms of one's own position are both hallmarks of improved ethical reasoning. Third, studying ethics should lead to better behavior. This is probably the most natural desideratum for studying ethics and yet, in the context of the classroom, it is difficult to make it a reality. How does one create opportunities for practice/repetition? Certainly, placing students in tempting and ethically challenging circumstances is a non-starter. Educators can construct hypotheticals but these only take the students so far. Some courses purport to teach ethical behavior via community service but, sans critical reflection and discussion (as well as the choice to do something other than what's directed in the course), such undertakings do little more than push a certain standard of behavior. While potentially valuable, this misses the point of ethics education in the most robust sort of way. Ethical behavior requires not only action but reflection and the absence of compulsion (e.g. a course requirement/grade).

It seems the best hope, in a classroom setting, to improve ethical behavior is through gains in the first and second goals. That is, educators are often left with the hope that enhanced ethical sensitivity (first overarching goal) and improved ethical reasoning (second overarching goal) will lead to better behavior. Despite the fact that sensitive, ethically intelligent people can and do act unethically, we believe this hope is a well-founded one. This, then, motivates the structure of the SIA which hopes to both increase ethical awareness and improve reasoning. The SIA is not a panacea assignment. But, we hope, it can meaningfully contribute to the more significant aspirations of engineering ethics education.

We are agnostic on how the SIA may contribute to decreasing academic dishonesty or towards preparation for the F.E. With respect to the latter, there is reason to believe that a different assignment would be better suited to F.E. preparation. The ethics portion of the F.E. tends to focus on narrower, more sharply defined questions than those raised in the SIA. This does not mean, however, that the questions raised in the SIA are not important.

Anatomy of the SIA

The SIA is not a new approach to ethics education. It does, however, hold several advantages over the more standard case based approach typical of many applied ethics education efforts. To be sure, case studies have their place in ethics education. Cases often prove to be effective introductions to engineering ethics; engendering student engagement early on. Insofar as actual examples, or realistically constructed hypotheticals, are used, case studies can be a good introduction to the profession. However, cases alone are insufficient. Without the right set up/instruction, case based discussions often do little more than ping pre-reflective intuitions. While this is descriptively valuable, it does not address the second overarching goal of ethics education – to improve ethical reasoning. Additionally, cases based on actual events such as the Challenger disaster or, more recently, the Minnesota bridge collapse or Gulf oil spill[1] benefit from the perspective of hindsight. It is easier for students to identify what should have been done differently insofar as many, if not all, of the major consequences have played out. While this is beneficial, it does not address the preventative dimension of engineering ethics which should be the focus of engineers in practice. Our students must cultivate the ability to effectively engage ethical challenges before short and long term consequences fully coalesce. The forward-looking emphasis of the SIA provides one opportunity to do so.

First, we will consider the SIA in its usual form followed by a brief discussion of several of the steps. Later in the paper, we will discuss how these instructions might be modified or emphasized differently given the context the SIA is used in. Here, then, are the instructions:

1. Identify and research a current engineering design, product, or concept that is (or soon will be) impacting society. The design, product or concept must be documented and patented or copyrighted. Class projects are not eligible for this analysis.
2. Your research should include several in-depth and credible sources of information on the design, product, or concept. You may use the Internet but you should also research journal articles to find qualified documentation that validates the authenticity or reliability of your topic.
3. Address the following in your paper:
    a. Provide background on the design, product, or concept. Who is responsible for creating/producing/building it and what need is it intended to fill?
    b. What positive consequences are anticipated for:
        i. The company responsible for the new design/product?
        ii. The users of the design/product?
        iii. Those not directly using the design/product but nevertheless affected by it?
        iv. You?
    c. What are the downsides of this design/product? What actual and/or potential negative impacts will it have on society?
    d. What can be done to minimize the negative impacts?
    e. Should this design/product be continued? Discontinued? Explain your answer.
    f. Which guiding ethical principle(s) applies here? Justify your answer.

To be most effective, students should be required to choose a design/product/concept (DPC) whose impact (positive and negative) has yet to fully play out. In this form, students are given a

fair amount of latitude regarding the topic of their analysis. Ideally, they should be encouraged to choose a DPC they are likely to encounter in their specific fields (e.g. structural engineering, pulsed power, etc.) and/or are particularly interested in. In our experience, this latitude leads to greater interest and even effort on the part of the student.

Prohibiting the use of class projects cuts both ways. While this rules out a potentially interesting topic of discussion for the student, it also screens out highly speculative and otherwise superficial analyses. Sources can include material about the DPC itself as well as parallel, established DPCs that students believe are relevant to the current one. Insofar as the latter tack is adopted, students should be asked to explain why the parallel DPC is relevant. This engages analogous reasoning which often provides a basis for generalized guiding principles of action.

Students are required to identify actual and potential negative impacts of the DPC. We have penalized students for including little to no discussion of the negative impacts of a DPC. The assessment of negative impacts should be wide-ranging. The assessment should canvass issues that arise (or are likely to) in production, implementation, and disposal (lifecycle). Students should not simply focus on immediate, health related impacts. Rather, the economic, psychological and even spiritual impacts of the DPC should be considered.[2] This requirement to enumerate and consider the negative impacts of the DPC pushes against the panacea mentality that some students have viz. new technology.

In determining how to mitigate or eliminate the negative impacts of a DPC, students should consider both technical and non-technical solutions; doing so reflects the complex set of conditions practicing engineers find themselves in. This aspect of the assignment engages the problem solving that comes so readily to many of our engineering students. From here, it is a natural segue to ask our students to assess whether or not the DPC should be continued/implemented. In this step, heaviest emphasis should be placed on the rationale provided in support of their decision. Steps 3e and 3f above promise to be the most revealing about the students' reasoning process. This is valuable for student and instructor alike. Assuming there is time to address the rationale, these steps provide some of the best teachable moments viz. ethical reasoning.

SIA in an Engineering Ethics Course

Because a stand-alone ethics course dedicates so much time to the topic, it is also the most forgiving regarding when to most effectively incorporate the SIA. That being said, we argue that it makes the most sense to utilize the SIA after students have spent time learning about ethical reasoning itself (e.g. ethical theory and/or in-depth analyses of several codes of ethics). A stand-alone engineering ethics course offers probably the best opportunity to explicitly focus in on how students think about ethics with an eye towards improving that thinking. Utilizing the SIA before students have had a chance to think carefully about the fundamental principles[3] that underwrite engineering practice risks undercutting the full value of 3e and 3f. This approach, where teaching ethical theory is front-loaded, is fairly standard. It is also not without some criticisms.

It is beyond the scope of this paper to mount a full scale defense of the value of ethical theory in applied ethics courses. However, some quick comments are in order. At least two challenges can be raised regarding the inclusion of ethical theory in an engineering ethics course. First, the value of ethical theory has been attacked on philosophical grounds. The traditional approach of beginning with ethical theories such as utilitarianism or deontological ethics and applying these to problems in medicine, law, engineering, etc. has fallen out of favor in some circles.[4] This approach is thought to be too simplistic and unjustified. Second, including ethical theories in engineering ethics is pedagogically problematic. Studying ethical theory often requires a paradigm shift on behalf of the students. The kind of abstraction and self-reflection required by a robust approach to ethical theory is, at best, a departure from the coursework they are accustomed to. Uncontroversial positions are not often emphasized when studying theory, which can lead to frustration and a kind of pseudo-relativism on the part of students.[5]

One response to the philosophical challenge mentioned above has been to emphasize, nearly exclusively, case studies. As already mentioned, this approach has its own drawbacks. At best, an approach exclusively emphasizing case studies is incapable of examining the relationship between cases (for the sake of precedence setting and justification). At worst, the approach does little more than give students an opportunity to state their pre-reflective beliefs which can and do include problematic biases.

More recently, a middle position, referred to as wide-reflective equilibrium has been developed in response to both of the philosophical concerns discussed. According to this approach, both case study analysis and general ethical principles have a role to play in our deliberations. Rather than assert a unilateral relationship from principles to cases (or vice versa), a bilateral relationship emerges where tensions between cases and principles are sometimes resolved in favor of the former and sometimes in favor of the latter.[6] Whether adopting the traditional approach described above or wide-reflective equilibrium, then, philosophical principles (theory) have an important role to play in ethical deliberation. The principles embodied in ethical theories underwrite the engineering codes of ethics. In short, theory has a place in engineering ethics education.

The pedagogical challenge above can, like so many others, be defused with strategic teaching. In our experience, introductory comments about the nature of philosophical inquiry coupled with the point that the students are already using several of the principles embodied in the theories can facilitate better understanding of the value of ethical theory. Studying ethical theory is much like stress testing a material. In both instances, we are looking for strengths and weaknesses given various stresses. Studying theory can lead to stronger reasoning much the same way stress testing a material can lead to more durable products. Furthermore, in our experience, practicing engineers who study ethical theory as a part of continuing engineering education often praise its usefulness. At the end of the day, paradigm shifts, even intellectually uncomfortable ones, are often invaluable.

The SIA, then, should come after both a primer in ethical theory and, ideally, a discussion of several engineering codes of ethics. Studying theory not only stands to improve ethical reasoning but ethical sensitivity as well. Principles can, in other words, help bring to light issues that otherwise might have gone unnoticed. This will be helpful when analyzing the positive and negative impacts of the DPC chosen for analysis. An early emphasis on reasoning will also lead to a more valuable analysis in sections 3e and 3f of the paper.

The SIA should also be the most evaluation intensive in this context. We work to provide individual, detailed feedback on student analyses. Allowing students to submit multiple drafts can lead to increasingly nuanced analyses. This outcome is not without its own challenges – we will discuss these later. More recently, the SIA has been used as precursor to a more in-depth research paper in the engineering ethics course taught at Texas Tech University. This setup was just used in the Fall of 2011 so it is too early to assess the effectiveness of this approach. At a minimum, however, it did help unify an early emphasis on fundamental principles with the capstone assignment for the course.

The SIA can also provide excellent fodder for in-class discussions whether between students and instructor(s) or simply between students. At Texas Tech, virtually all of the majors offered in the Whitacre College of Engineering are routinely represented in the stand-alone course (not, unfortunately, in equal numbers). This plurality has led to valuable discussions among students. In such a setting, students can no longer rely upon the biases of their individual majors. Petroleum engineering majors, for example, are often prompted to think more carefully about their own pro-industry biases when discussing recovery techniques with environmental engineering majors. SIA discussions fit very naturally in this setting and it would be worthwhile to allow students to revise their SIAs after group discussion/critique.

SIA in an Engineering Communications Course

Though not focused on ethics per se, a course teaching engineers the fundamentals of communication (verbal, written, presentation, etc.) is a very natural place to include ethics content. Some of the challenges we face in ethics are as much a function of communication problems as they are of conceptual differences. Likewise, making practical and substantive headway on ethical challenges requires effective communication skills. In this context, both the written and research dimensions of the SIA should be emphasized. The SIA provides an opportunity to develop effective research skills and can help students identify credible research sources.

One challenge for engineering students is making a logical and convincing written argument and presenting that argument by giving an oral presentation. Providing them with an venue in which they are the experts because they pick the DPC topic, which is approved by the instructor, and conduct research about the topic, they have knowledge and expertise about the topic that the instructor does not have; thus, replicating what they may be doing in industry once they graduate; presenting a proposal and presenting both the negative and positive aspects about the proposed project. The instructor has little knowledge of the DPC topic, giving the instructor the role of novice and the students the role of experts. An added benefit to this is the knowledge that the instructor gains about a DPC topic. In industry, engineers are expected to be able to provide

information that is not otherwise known and to present an argument why something should or should not be done. Students and practicing engineers must make decisions on designs and implementation of designs and struggle with the impacts that the design will have on society. It is, therefore, beneficial for students to have the experience of presenting an argument based on ethical decisions before they leave the university and enter the professional world.

Though ethical theories are not emphasized in an engineering communications course, this does not mean the timing of the SIA is a non-issue. At a minimum, students should be taught about the importance of effective communication and be given guidance on how to properly conduct research and present a sound argument on a decision that they have made. This groundwork can help provide both motivation and means for an in-depth analysis. In the communication course taught at our university, the SIA is the capstone assignment. It has both a presentation and written component. More recently, a guest lecture in engineering ethics has been incorporated prior to the SIA. This lecture is intended to provide further motivation for the SIA as well as acquaint students with sources of potential guidance (e.g. fundamental ethical principles and the engineering codes of ethics).

The emphasis of an engineering communications course strongly suggests the inclusion of both a written and oral presentation component for the SIA. And while an engineering communications instructor is likely to look for different things in sections 3e and 3f, students should still be expected to develop and defend a rigorous position regarding the continuation/implementation of the DPC they researched. Rather than be expected to apply the Principle of Utility or Kant's Principle of Universality, it may be more appropriate to expect students to apply several canons from their discipline's code of ethics. Even here, there is opportunity for in-depth discussion. Explaining which canons apply, how, and why can help improve students' ethical reasoning. In this regard, then, the SIA continues to support the overarching goals of ethics education. Prior to conducting research for the SIA, students are given a mini-assignment—Code of Ethics Assignment—where the students are to research the code of ethics in their discipline, read the cannons, and write a summation of what they learned about ethical issues in their discipline. The students put in teams of two for the SIA assignment.

Coaching on how interpret and incorporate both technical and non-technical research sources can, ultimately, help enhance student sensitivity. If, for example, a student is narrowly focused on the physical impact of a DPC based on its technical specs, the communication instructor may take this opportunity to encourage the student to look at newspaper articles and other non-technical sources of information about the DPC. Credible non-technical sources about a DPC (or related DPCs) are more likely to discuss the secondary and even tertiary impacts of a DPC. In these sources, for example, the economic impact of a DPC may emerge more clearly than it does in a technical source. Insofar as students walk away with an awareness of these additional impacts, they stand to enhance their ethical sensitivity.

Making the SIA the centerpiece of a communications course also means that instructor evaluation and feedback will play a key role in the analysis. Though time intensive, students should be given feedback on an individual basis. They should also be allowed to revise their SIAs in light of instructor (and perhaps peer) feedback.

The students are given examples of previous Design/Product/Concept (DPC) topics, and then assigned to find their own topic; they are encouraged to ask professors in their discipline or they can research online for new topics. Because the professor is interested in learning about new topics, the topics also must be new to the instructor. Suggestions such as searching ASEE's *Prism* magazine or technical journals help students to get headed in the right direction. Topics can range from Kilobots to Polymer Cartilage Scaffolding. After the topics are approved, students then work in teams of two to research, develop rough draft papers which are peer-reviewed in class, and then submit final papers and oral presentations using PowerPoint slides.

Finally, students should be encouraged to demonstrate which ethical challenges highlighted in their SIA have their origins in communication breakdowns and which challenges are the result of more fundamental differences. Identifying the former can provide additional motivation for the course (important especially for those students who question the inclusion of a "soft" skills course in the curriculum). Doing so can also lead to a more sophisticated understanding of ethics in the practice of engineering.

Because the communication course is a Service Learning course and students work with a civic organization (client) for their class project, student reflections are extremely important to see how the students use ethical consideration during their design process. More importantly, ethical considerations should be evident in their final report which is submitted to the client. The client needs to see that students are considering issues other than technical issues when they submit their design and make a sound argument for their design.

Students submit three reflection papers during the semester, and the reflection papers are graded only if they address the question and not graded for grammar or punctuation so that students feel free to express themselves without worrying too much about technical writing issues. However, for the most part, the students' reflection papers are very well written. It is at the end of the semester that the students' reflection papers best exemplify what they have learned about the service learning assignment and what they have learned about considering ethical issues during their project. Some examples of students' final reflections are:

Student #1: *Being involved in the service learning project, my idea on the work on what professional engineers do and the responsibility that engineers have to society is changing. I previously had no knowledge that when an engineer does work for a client, they must take into consideration how it will affect the rest of society. I now know that one of the biggest concerns of engineers is how a project will affect the environment. Engineers are constantly trying to figure out ways to complete a project while allowing it to be friendly to the environment. It seems these days that everyone is "going green" and engineers are no different. Engineers should not only do this because many times legal matters are involved, but also because it is the right thing to do. There is only one world and it needs to be taken care of. When engineers partake in a project they should also try to advance human welfare. This can include a variety of things from reducing poverty to educating the community.*

Student # 2: . *Engineers must participate in society as they aim to improve it. They must be constantly held accountable for their actions, and this is done in the team setting. If the team produces something all of the team's members will have their names affiliated with it for good or*

for bad. Engineers have the responsibility to society to design the best possible products while still being held ethically accountable for their actions, and an important responsibility it is.

Student # 3: *Personally, this experience has definitely enhanced my perception of what a professional engineer does. With the knowledge gained in school and in industry, engineers are very powerful individuals. It is very important to constantly revisit professionalism as well as ethics when your profession directly effects* [sic] *people. This is why it is very important to carry oneself in a professional manor and to always remember the profound effect engineers can have.*

Introducing students in the communication course to ethics and requiring them to apply what they have learned about engineering ethics to a service learning project gives them actual experience in considering ethical issues when they become practicing engineers.

SIA as a Stand-Alone Assignment

ABET has granted broad latitude to engineering colleges/departments regarding how they meet the ethics component for certification. This has led to some programs requiring a stand-alone ethics course whereas others have opted to integrate ethics into technical courses.[7] In the latter scenario, it is not uncommon for instructors to introduce case studies for analysis and discussion. Indeed, at Texas Tech some students are required to watch one of the several ethics videos produced by the National Institute for Engineering Ethics whereas other instructors opt for standard cases in engineering ethics (e.g. Challenger, Hyatt Regency collapse, etc.). For reasons already discussed, case studies alone are not enough to meet the overarching goals of ethics education. In this section, we will discuss several ways the SIA may be incorporated into a technical course.

The most ideal of this integrated approach would be to assign the SIA as a written assignment in advance of a lecture/discussion. In this first iteration, students are still given the opportunity to choose the topic of their analysis. The instructor would spend time setting up the assignment and explain her expectations. Students would be given at least 1-2 weeks to complete and submit their written analyses. These would, in turn, be evaluated and returned with comments by the instructor. Assuming that the course is technical in a nature, many instructors may feel uncomfortable providing critical feedback on those portions of the SIA requiring students to explain and justify their reasoning. This may lead to instructors omitting the reasoning portion (e.g. 3e and 3f) or otherwise downplaying it. Doing so, however, would be a lost opportunity.

In a time when academic silos are being torn down, it is not beyond the pale to think that an instructor in the situation above could partner with someone within the college/department who has developed some level of expertise in ethics education. However, many of us are too pressed for time to seek out even this level of collaboration. Even given this, thoughtful instructors are capable of putting challenging questions to students. Well formulated questions can go a long way towards helping a student improve his/her thinking about ethics.[8] Instructors need not be able to answer these questions to help their students improve their reasoning. Even without

critical feedback, the process of explaining and justifying one's reasoning process is a valuable undertaking.

Finally, in this first iteration, the course instructor would dedicate at least one class period to discussing student SIAs (perhaps as student presentations) after the written evaluations have been returned. Here as much time, if not more, should be spent discussing the SIAs as is spent presenting them. This arrangement would allow students to enhance both their ethical sensitivity and reasoning through instructor and peer feedback.

Given the pressure to cram as much content as possible into a given course, the first iteration may be more time consuming than is feasible for many instructors. A second, more attenuated iteration of the SIA would feature a common topic for all the students to analyze (on their own). Here instructors could develop a universal comment/feedback form to give to students after they have submitted their written analyses. The class discussion would still be an important component of this iteration; ethical growth is often the result of dialectical interactions.

If the first two variations are too homework and evaluation intensive, the SIA can also be converted to a lecture centerpiece. In this iteration, instructors would choose and setup a DPC for discussion. The instructions for the assignment provide an outline for discussion. As with previous iterations, emphasis should be placed on discussion. Instructors should lead but not dominate analysis of the DPC in question. One of the most valuable things the instructor can do is to ask challenging questions in response to student comments. Students are sometimes hesitant to constructively criticize each other. An instructor can overcome the resulting silence with several well placed questions.

In both writing and discussion, students should be encouraged to explicitly formulate principles that are applicable to their analyses. The challenge, when using the SIA as a stand-alone assignment, is the lack of groundwork dedicated to fundamental ethical principles and reasoning. In this situation, at least a couple of options are available to instructors.

First, instructors may opt to distribute and discuss the code of ethics most relevant to the class (e.g. ASCE Code in a structures class). In this scenario, students would be encouraged to choose one or more portions of the code that apply to the SIA. Students should be expected to do more than simply state which portions apply. Rather, they should explain why said portions apply and draw out any potential or actual tensions between the portions. The more detailed the application (e.g. defining who counts as the "public" in the analysis), the better. Again, this is a valuable exercise for the students even without critical feedback by the instructor.

More controversially, students may be encouraged to apply their own background beliefs about right/wrong to the SIA; including religious beliefs. Doing this represents something of a departure from the received wisdom of cordoning off religious beliefs from applied ethics discussions in the classroom. However, asking students to disregard their fundamental views about how we ought to treat people when taking up challenging questions risks framing the SIA as an intellectual exercise and little more. The difficulty here, for student and instructor alike, is to allow students to apply their beliefs without treating these beliefs as above critical discussion. The fact of the matter is that Christian engineers will interact with Muslim engineers who will interact with Buddhist engineers and so forth. Students must develop the skills to effectively engage this pluralism. Many religious principles have analogs in both the fundamental theories

studied in an ethics course and even in the engineering codes of ethics. Finding common expression of principles that hail from different metaphysical backgrounds is not as overwhelming as it may initially appear to be.

SIA: Challenges and Responses

We have spent time discussing the limitations of case studies in ethics education. However, one of the strengths of using well defined case studies (either in the form of constrained examples from real life or narrow hypotheticals) is the ability to keep discussions tightly focused on decisions immediately available to engineering students. That is, well defined case studies allow instructors to focus on the dimensions of engineering practice that students most easily identify as being within their control. As discussions become more wide-ranging and complex, they often involve decisions makers outside of engineering. This creates a sense of dispersed responsibility. As problems involve more parties and implications reach further out, engineering students sometimes take less ownership and thus engage less. Moreover, there is a common, somewhat understandable, push back against attempts to extend an engineer's obligations. Though not absent, this push back is less pronounced among practicing, experienced engineers. There seems to be a greater sense of commitment to the public health, safety, and welfare among the latter group. Nevertheless, it is easy to see how the SIA could lead to the kind of overwhelming complexity and subsequent disengagement alluded to above.

Two additional tendencies among students add to the challenge of effectively implementing the SIA in any context. First, it is not uncommon for engineering students to portray themselves as passive players in the development and deployment of technology. In our experience, many students tend to view themselves as merely executers of designs. On this view, engineers are to take the needs and desires of decision makers and translate them into a tangible reality. In doing so, these students try to offload responsibility for some of the bigger questions that arise in the process. The disconnect, of course, is that it is often the engineers who are the most knowledgeable about the strengths and limitations of the technology in question.

Second, some (though not the majority in our experience) students voice a hired gun mentality. Their job, as they see it, is to do what their boss tells them to do. As long as they (the students) are legally covered, it is not their place to engage the challenging questions raised in engineering practice. Add to this a cynical view about the role of ethics in contemporary engineering and instructors are faced with the daunting challenge of getting these students to thoughtfully engage any discussion of ethical responsibility (or opportunity).

With respect to the second tendency, cynicism is hard to counter in its most ardent forms. Whether the result of immaturity or life experiences, instructors sometimes need to concede that some students will not "see the light"; at least not right away. This concession should not be made until after attempts are made to acquaint the students with the full implications of the view they have adopted. Similar conversations about the implications of ethical relativism can lead to greater engagement on the part of students who, at the end of the day, embraced a faux version of relativism. More specifically, some students back off of their cynical views when it is demonstrated that simply following directives entails conceding professional autonomy that is, among other things, based on an engineer's hard fought knowledge.

The first challenge above is not dealt with as straightforwardly. The fact that the SIA focuses on the broader impacts a DPC will have on society, coupled with its forward-looking emphasis, means that analyses promise to quickly get complex. But, while such complexity makes for a somewhat "messier" educational experience, it also reflects the conditions that practicing engineers find themselves in. This is especially true for those engineers who leave technical positions for managerial and executive roles. We do our students no favors in oversimplifying the problems they are likely to encounter. Technology is becoming increasingly complex and, in some respects, difficult to manage. This, in part, explains why decision makers (whether in the public or private sphere) are struggling to make fully informed decisions about technology. Engineers, more than ever, need to play an active role in the smart application of technology. We will have reached an untenable position if those making decisions about technology are uninformed while those who are informed remain passive participants.

Even if the comments above are naïve and unduly pessimistic, it remains the case that the complexity uncovered in the SIA creates an opportunity for discussion. It can lead very naturally to fruitful discussions about the nature of proportional responsibility, the assessment and communication of risk, and the role of engineers in an increasingly globalized society.

SIA in K-12 Education

For the past two years, the T-STEM Center[9] at Texas Tech University has hosted the Exxon Mobil Bernard Harris Summer Science Camp.[10] The camp provides an intensive two week educational experience for incoming 6th, 7th, and 8th grade boys and girls. The camp features a variety of activities for the students and a core project. In collaboration with the National Institute for Engineering Ethics (NIEE), T-STEM incorporated ethics into the core project of each camp. We found that students were remarkably receptive of and engaged with the ethics content. In each case, the lecture delivered was, essentially, comparable to one found in an introductory ethics course in college. That the students were so interested in the lecture and ensuing discussion is all the more remarkable given that they were not intellectually exceptional students. Many of the students were fairly typical regarding academic performance. This experience, coupled with other camps and forms of educational outreach, has prompted T-STEM and NIEE to consider how the SIA might be incorporated into K-12 education.

Because K-12 students have, in most cases, not developed the kind of biases discussed in the challenges section above, the SIA may be most effective when used in the K-12 context. It can function both as an educational tool and as a recruiting tool. The SIA can breathe life into the practice of engineering; simultaneously educating young children about what engineering is and exciting them about the positive impacts they can have on the lives of others. The SIA reveals engineering for what it is – a complex but intrinsically interesting endeavor. We argue that students, armed with a more robust sense of engineering obligation, will be more resilient to the kind of cynicism and even passive mentality discussed earlier.

As with the other contexts, incorporating the SIA is not without its challenges. One of the more immediate challenges T-STEM staff face in their outreach is the broad variety of access to resources. For some schools and students, high speed internet access is fairly basic. Yet, for

others, this is a luxury item (especially in rural, impoverished areas). The SIA, then, must be utilized with these kinds of disparities in mind. Researching DPCs on an individual basis may be a non-starter. However, as a class, this may be more feasible. Students can be provided with the background information necessary to analyze a DPC (hard copies of accessible journal articles, newspaper articles, etc.). An even less resource intensive route would be to allow students to create/imagine their own DPC. Teachers should help facilitate a detailed description of the DPC. For example, students should be asked to think about what materials will be used in producing the DPC, how these materials will hold up over time and how they will be disposed of upon obsolescence.

The T-STEM Center has placed recent emphasis on educating educators about STEM with an eye towards maximizing impact. This emphasis on teachers is appropriate regarding the inclusion of the SIA in STEM education. K-12 teachers should be provided with example DPCs as well as easily accessible and credible sources for DPC research. Additionally, guidance on how to incorporate ethics into the curriculum should be provided. Given that K-12 educators have less latitude regarding curriculum content, it is critical that ethics educators work closely with their K-12 counterparts to develop effective ethics content that lines up with state and national performance standards.

Ideally, the SIA will be incorporated into the curriculum after students have had some exposure to STEM projects (e.g. rocketry, robotics, etc.). This helps lay a foundation for discussion. However, due to time limitations, this may not be feasible. In such situations, the SIA, perhaps in a more limited form, should be incorporated into a STEM project. We have had past success, for example, creating breakout discussions about the social implications of robots in a Lego Robotics camp. This integrated approach also conveys the key notion that ethics is integral to the practice of engineering versus, at best, an afterthought.

Utilized effectively, the SIA has the potential to promote increase awareness of the dual nature of technology (i.e. it's positive and negative impacts) and the complexity of engineering. Far from scaring students away from STEM disciplines, the SIA can actually generate excitement about the kinds of challenges engineers face. The SIA can desterilize engineering.

Conclusion

The SIA is not intended to be an all encompassing approach to ethics education. Nor, do we claim, is it a wholly new and innovative ethics assignment. It does, however, represent a departure from the case oriented approaches characteristic of many attempts at teaching engineering ethics. This departure, we argue, is an advantage for the SIA.

Our hope has been to show that the SIA lines up well with two of the three overarching goals of ethics education (increasing ethical sensitivity and strengthening ethical reasoning) and that it can be instrumental in meeting these goals in a variety of contexts. While we outline several possible contexts for the SIA (and for engineering ethics education in general), we do not view this list as exhaustive. We invite our fellow instructors to modify the SIA as they see fit; improvements are welcomed.

Finally, we have pointed out that, while messier than tightly focused case studies, the complexity uncovered when analyzing the social impact of a technology is invaluable as a teaching tool. It

reflects the realities of contemporary engineering and can serve as a clarion call for greater engagement in key decisions about the application of technology. Our own view is that engineers ought to be more involved in decisions about deploying the technology that affect us all.

References and notes

1.This is not to imply that all the dust has settled with respect to the oil spill. The full impact of this disaster is not likely to be known for some time yet.

2. We do not allude to this range of impacts in the instructions. The omission is intentional insofar as it left to the individual instructor to determine how to introduce and encourage a broad impact assessment.

3. We will refer to this "ethical theory" though it is possible to discuss ethical principles and reasoning without delving too much into classical or contemporary ethical theory.

4. The Stanford Encyclopedia of Philosophy has a comprehensive, accessible discussion of this topic. "Reflective Equilibrium," last modified Jan. 12, 201, http://plato.stanford.edu/entries/reflective-equilibrium/

5. This disdain for studying ethical theory is certainly not unique to engineering students.

6. "Reflective Equilibrium"

7. In an ideal world these are not mutually exclusive. Sans the constraints of contemporary engineering education, ethics should be taught as both a stand-alone course and should be thoughtfully integrated throughout the curriculum.

8. This is a point that Michael Davis makes nicely in his article "Integrating Ethics Into Technical Courses: Micro-Insertion", *Science and Engineering Ethics* vol. 12, no. 4 (2006), pgs. 717-730.

9. http://www.depts.ttu.edu/tstem/

10. http://www.theharrisfoundation.org/sitecontent/565/summer-science-camp/category/457/education.aspx