Integrating Ethics in Undergraduate Engineering Economy Courses: An Implementation Case Study and Future Directions

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Abstract

The integration of humanities, social sciences, and writing into the engineering disciplines has been shown to improve critical thinking and creativity in students. Undergraduate Engineering Economy courses are well-positioned to facilitate such integration because of their cross-disciplinary nature. One humanities topic that fits particularly well within Engineering Economy courses is ethics, which in many ways is already woven into the content through existing textbooks. Nevertheless, the variety of methods used to deliver Engineering Economy courses (e.g., traditional classroom, large lecture hall, online, hybrid) provides ample opportunities to improve and refine how the topic of ethics is addressed. This paper presents an overview of the implementation of an ethics-based learning module in an undergraduate Engineering Economy course. The module was part of a pilot effort for what is anticipated to be a broader implementation spanning several instructors, locations, and delivery methods. The centerpiece of the learning module is a writing assignment in which students analyze a historical case in which financial considerations appear to have played a role in the violation of ethical codes or norms. In this paper, we outline specific ethics concepts that were brought up during classroom discussions regarding this writing assignment and provide a qualitative assessment of how well students applied ethical considerations in their analyses of the various case studies. The module also includes a survey intended to explore the attitudes of students related to professional ethics, their perception of ethics education in their curriculum, and how they view the relationship of engineering practice and financial decisions. Based on our assessment of this first implementation, we discuss how the module might best be modified to accommodate other delivery formats and present our views on the most appropriate timing of the module in relation to the course calendar. We also explain our views on how ethics should be approached within the context of Engineering Economy courses and what factors might influence the decision to adopt either a micro-insertion or macro-insertion instructional approach. Finally, we outline an approach for future research aimed at assessing the current state of ethics instruction in Engineering Economy courses for the purpose of clarifying which instructional technologies, techniques, and strategies might be most effective.

Introduction and Background

Integrating humanities studies into engineering technology curricula is a central component of the transformation taking place at Purdue Polytechnic. Even as enrollment trends for humanities majors have been declining in recent years [1], there are still consistent calls for humanities topics to be a part of STEM education [2-4]. Unfortunately, adding additional content to already packed STEM curricula can be very challenging for institutions operating under total credit hour restrictions. One promising strategy for incorporating humanities into STEM courses is to strategically weave the individual humanities topics into existing courses. Toward this goal, the college has incentivized the development of modules, lessons, or class projects that have a clear humanities-based learning objective and have the potential to reach many students. The module described here was funded for development through an internal grant, and this paper presents a

summary of the module's content, the rationale for its approach, reflections on some of the key assumptions of the rationale, and recommendations for others wanting to implement a similarly-styled ethics assignment.

Most Engineering Economy instructors would probably agree that these courses are well-suited for reaching large numbers of students due to their cross-disciplinary nature and are also well-suited to discussing professional ethics because of their connection to the world of Management. Unfortunately, there is some evidence that engineering students do not receive the same level of instruction or feel the same level of engagement with ethics as their counterparts in business schools [5]. Given the importance of professional ethics, it is worthwhile to take steps to help future engineers feel engaged with professional ethics, to help them learn to navigate ethical dilemmas, and to help them recognize ethical problems in the workplace. This was an underlying motivation for developing this module, which is a stand-alone ethics lesson and writing assignment for a 300-level undergraduate Engineering Economy course. The course is coordinated by faculty in the Industrial Engineering Technology program and is specifically required for no fewer than five engineering technology bachelor's degree programs offered in the college. It is delivered in a variety of formats by several faculty and full-time instructors.

Module Content

The module's design was tailored to be most effective in smaller sections of 25-35 students where classroom discussions are possible, although from the beginning the needs of large traditional classrooms and online sections were taken into account. The module's classroom time requirement is estimated to be 1.5 hours and it is intended to be administered over the course of 2 or 3 meetings early in the semester. The early-semester introduction was intentional, as the module serves to both introduce the topic of financial analysis and familiarize students with the unique ethical considerations that stem from financial decision-making. Although not strictly by design, the early delivery aligns well with the designated course textbook [6]. The module is comprised of the five components summarized in Table 1, and the individual components of the module are described in more detail in the paragraphs ahead. The majority of the lesson content was drawn from general ethical concepts and ideas as described in *Engineering Ethics, Concepts & Cases* by Harris, Pritchard, and Rabins [7].

The learning module opens with a survey administered via a physical handout. The intent of the survey is not data collection, but rather to give students the opportunity to reflect on their prior experience with ethics instruction in their degree program and to reflect on their own perceptions of what constitutes ethical practice. Most survey questions were drawn from a previously published study investigating student engagement with ethics across a business and an engineering program [5], while a few were developed specifically for the lesson. Student responses along with comparison results are presented in Appendix A. A short instructor-led discussion covering some of the survey questions takes place immediately following the survey, providing students with an opportunity to share their initial thoughts. A main point of emphasis for the discussion is exploring the rationale for believing that profit maximization either is or is not an ethical obligation.

Table 1 – Module Components

Week/ Class	Component	Description	Class Time Req.
1	Survey	Ethics Engagement, Attitudes, and Perceptions. Given to orient students to concepts and terms and to prime students for discussions.	15 min
	Lecture & Discussion	Lecture & guided discussion: Universal and personal morals versus professional ethics. Introduction to the Code of Ethics for Engineers. Discussion of select Canons and Rules of Practice relevant to financial analysis. Point-counterpoint discussion using the Ford Pinto case.	30 min
2	Writing Part 1 Review of Cases	In-class discussion of several case studies: Focus is on students' initial perceptions of the cases, moral and ethical dimensions of the cases, and financial aspects that should be considered in any decisions. Artifact is a short summary of one case.	~ 20 min
	Writing Part 2 Analysis	Reflective/analytical writing: Examining a case study from the ethical/financial perspective. Students are given approximately 1 week to complete the study, and another week is necessary for evaluation. Subsequent debrief session occurs after evaluation. Artifact is a 2-page paper.	0
3	Debrief	Classroom discussion after writing assignments have been evaluated. Purpose is to highlight instances where students clearly have linked ethical or unethical behavior in a case to the Engineering Code of Ethics. Survey results are presented to the class in aggregate, and students are invited to reflect on how their initial responses may have changed during the course of the writing.	~ 15 min

The lecture portion of the module immediately follows the discussion. It is designed to introduce students to the concept of universal and personal morals and to highlight distinctions between moral concepts and professional ethics. Great care is taken to keep the instruction of ethics to a level appropriate for the course and what would likely be within the comfort level of most instructors. Students are then introduced to the moral concepts of Universalizability and Reversibility and their connection to ethical decisions. These concepts are both analogous to the Golden Rule, which is a principle common to many cultural and religious philosophies. Universalizability holds that "whatever is right (or wrong) in one situation is right (or wrong) in any relevantly similar situation" [7]. An example of how Universalizability applies to ethics and finance might be seen in the following example. An engineer is considering excluding a portion of data from an analysis that they believe to be (but are not certain) inconsequential to project outcomes and cost because they believe (but are not certain) the data are only marginally reliable. Applying Universalizability, the engineer also must consider whether it would be right to exclude similar data from similar analyses in similar situations, thus requiring them to look beyond the urgency of the current situation. The principle of Reversibility holds that we should act in ways that we believe would be appropriate if the roles were reversed [7]. Revisiting the previous example, if the engineer determines that excluding the data is morally acceptable, it is natural that a decision about whether or not to inform the client might follow. Applying the concept of Reversibility to the situation, the engineer should act in a manner that would be

acceptable to them if the roles were reversed. In other words, the engineer must consider whether they would want to be informed of the exclusion if they were the client. The discussion concludes by reminding students that while there are sometimes no clear answers to such questions, there can be differences between morally and ethically acceptable choices. In other words, what an engineer determines to be a morally acceptable decision might fall out of bounds in terms of professional ethics.

Continuing the lecture, students are introduced to ethical decision-making from the Utilitarian perspective, and three different frameworks are described: the Cost-Benefit approach, the Act Utilitarian approach, and the Rule Utilitarian approach. The Cost-Benefit approach is quite appropriate to discuss given that many Engineering Economy texts have a chapter dedicated to Cost-Benefit Analysis. This approach calls for decisions to be made through a process of balancing a set of competing benefits and costs. The Act Utilitarian approach differs slightly from the Cost-Benefit approach in that it places an emphasis on defining an "audience" for the decision. The decision that brings about the greatest good for the appropriate audience, while also considering harms and adhering to the principle of Universalizability, is said to be the ethical decision. The third framework is the Rule Utilitarian approach, which emphasizes ethical rulemaking and finding a set of rules or policies that govern decisions for all persons in a certain set of circumstances. The example discussed in class involved traffic laws [7].

Moving on from ethical decision-making, students are introduced to professional ethics and the Code of Ethics for Engineers, which is published by the National Society of Professional Engineers (NSPE) [8]. Applying the NSPE code of ethics is a natural choice for the module since it is directly related to engineering and is readily available. The goals of this portion of the lesson are to help students firmly link both universal and personal morals to professional ethics and to highlight portions of the code of ethics that have a clear relationship to financial decisions. This was accomplished by examining the Preamble, Fundamental Canons, and Rules of Practice 2.a, 4.a, and 5.a of the code. After discussing the code of ethics, students were invited to share how they view the connections between the Rules of Practice and their specific discipline (e.g., Mechanical Engineering) and then to envision scenarios in which those same rules might apply to a situation involving a financial analysis or decision. Examples of discussion points that can be used are provided in Table 2. There are of course several Rules of Practice that can be applied, and this is another aspect of how individual instructors can tailor the module to best align with their expertise, experience, and personal interests or the interests of a particular class.

Concluding the lesson is a discussion of how examining case studies can be useful in learning to discern between ethical and unethical behavior in professional situations. During the discussion, two case studies from the Ford Pinto fuel tank situation were used to illustrate how professional ethics and financial considerations overlap. The first case presented the familiar version, in which an emphasis on cost-cutting seemingly led engineers to select an inadequate fuel tank design [9] that was responsible for fatalities. This first case provides a clear example of how financial analysis overlaps with ethical decisions. The second case study offered a countering perspective on some aspects of the situation and proposes that the selection of the fuel tank design may not have been an overt ethical failure in the ways typically thought [10]. In the end, most students agreed that the choice to leave the fuel tank design unchanged was a mistake, and a slightly smaller proportion thought the choice was a clear ethical failure. The discussion

Table 2 – Engineering Code of Ethics Rules

Rule	Example of an Ethical Conflict
2.a - Engineers shall undertake assignments only when qualified by education or experience in the specific technical fields involved.	**Discipline Specific:** A Mechanical Engineer agrees to analyze the suitability of an electronic controller in an unfamiliar application. **Financial:** The Mechanical Engineer agrees to make a recommendation on the financial viability of the make/buy decision for the electronic controller when they have not performed such financial analyses in the past.
4.a - Engineers shall disclose all known or potential conflicts of interest that could influence or appear to influence their judgment or the quality of their services.	**Discipline Specific:** An Industrial Engineer recommends a contractor who employs a close friend. **Financial:** The Industrial Engineer appears to understate potential risks associated with using their close friend's employer, making the financial analysis appear more attractive.
5.a - Engineers shall not falsify their qualifications or permit misrepresentation of their or their associates' qualifications. They shall not misrepresent or exaggerate their responsibility in or for the subject matter of prior assignments.	**Discipline Specific:** A newly licensed Civil Engineer states they have extensive expertise in analyzing drainage systems for new buildings, when in fact their role in such analyses has been minor. **Financial:** The Civil Engineer states they have experience developing cost estimates for new drainage projects, when in fact their responsibilities have been limited to monitoring budgets.

concluded with a question intended to directly link the Pinto case to modern practice: *If it was unethical for Ford to leave the Pinto fuel tank design unaltered due to cost implications, is it also unethical for automakers to leave advanced safety equipment such as lane departure warning off of some vehicles?*

Rounding out the module is a 2-part reflective writing assignment. In Part 1, students select three case studies that they believe feature both ethical and financial components. A list of preselected cases was presented for students to consider, although they were permitted to select case topics not on the list if they were appropriate. The preselected cases included the Volkswagen emissions scandal, Takata airbag recall, Deepwater Horizon disaster, the Ford Pinto case, and the Solyndra scandal. Web links were provided for these topics to help students begin their investigation, but they were strongly encouraged to look for information on their own. The assignment documents provide guiding questions intended to help students identify the ethical and financial aspects of the case, and students are invited to speculate on financial aspects if there are none that are obvious at face value. After students have had time to investigate the cases (1 week), a short class discussion is held that centers on hearing students' initial perspectives on the various cases. The purpose of the discussion is primarily to give students another opportunity to reflect on the ethical and financial dimensions by hearing from both their peers and the instructor. An assignment artifact for Part 1 is required, consisting of a list of cases reviewed and a maximum 2-paragraph summary of the ethical dimension of one of the cases. Flexibility for this portion of the assignment can be seen in how the instructor chooses to hold

the discussion, which may be done in class or online, and the ability for instructors to recommend cases for students to consider.

For Part 2 of the writing assignment, students select one case study for further review and write a 2-page reflective paper based on a set of guiding questions intended to help students outline the paper's structure (Figure 1). Students have one week to finish the paper. After the papers are evaluated, a short final debriefing occurs in which the instructor provides final thoughts on the work. At that time, students are shown a summary of the survey results that include comparisons to other student populations, which in this case were from the source paper [5] but in the future could be from previous semesters. Students were again invited to reflect on how they view professional ethics and ethical decision-making and how their perspectives might have changed as they reviewed the case.

Assessing the First Semester

From a qualitative perspective, the initial roll-out of the assignment was successful. Of the 19 students enrolled in the class, 18 completed both parts of the writing assignment. A plagiarism check using the SafeAssign feature of the Blackboard learning management system produced an average score of 8.0% with a max of 27.0%, which indicates the probability that text in a submission matches other sources. Most students were able to identify potential moral or ethical problems and were also able to draw appropriate connections between personal morals, the Code of Ethics for Engineers, and the situations described in the cases. Not surprisingly, students often took strong positions surrounding the central issue(s) in the cases. The main difficulty students had with was articulating a counter perspective when they perceived a clear ethical problem.

The papers were evaluated using a scoring rubric in which points were awarded for addressing the guiding questions (10 points), quality of writing (5 points), and how well they justified their final position on the case (5 points). The summary from Part 1 was evaluated against the guiding questions and quality of the writing in the summary (5 points). The average score for students completing both parts of the assignment was 21.16 points out of a possible 25 points. The most common case study topics selected were the Ford Pinto case (6 students), the Volkswagen emission case (3 students), and the Deepwater Horizon case (3 students). Other topics selected included the recent GM ignition recall, the Takata airbag recall, and a case involving the recall of Ford transmissions.

Reflections

As mentioned previously, the Engineering Economy course for which this module was developed is delivered using several methods, is taught by several instructors, and draws students from several programs. It is therefore appropriate to reflect on this first implementation and to reexamine some of the underlying assumptions that were made when designing the module in order to help ensure that future implementations will be successful. We discuss some of these reflections and assumptions as they relate to implementation at the college in the following sections and also share some general recommendations for faculty or instructors at other

institutions who may be interested in incorporating an ethics lesson in Engineering Economy courses.

Surveys

Because the primary purposes of the initial survey in this course were to prompt reflection by students and to facilitate a class discussion, any attempt to draw general conclusions would be inappropriate. However, the survey was useful in that it provided insight into the perspectives of students in the class. It was very interesting to observe in what ways students' attitudes tracked with findings from Culver et al. [5] and which did not (Appendix A). For instance, based on the surveys, a higher percentage of students in this class felt engaged with the topic of ethics than did students from the comparison group (S1-S3). This is a positive finding in and of itself and may indicate that students in the class had a more well-developed sense of ethical responsibility than the comparison group. On the other hand, some questions (S5, S7, and S8) seem to indicate the opposite, suggesting that students may perceive that their professional lives are somehow insulated against certain aspects of ethics.

Another surprising finding was the high level of agreement among students that maximizing financial gains and minimizing costs is an ethical obligation. This statement (S12) was developed specifically for the module. Profit maximization as a strict ethical responsibility has long been out of fashion in academic circles, but the survey results seem to suggest that students may view the matter differently. This notion was explored further during the discussions, which is certainly appropriate given that a good deal of time in any Engineering Economy course is spent selecting alternatives with the "maximum" net present value. In the future, the methods used to conduct the survey might be improved by leveraging technology (e.g., surveys taken online prior to the first class or in real time using iClicker-type technology) in order to enhance the value for students by providing instant insight into what their peers believe about some of the fundamental issues, such as profit maximization.

Timing

A key assumption that played into the design of the module was that the best approach would be to introduce it early in the semester in order to orient students to the importance of financial analysis. As with many engineering programs, Engineering Economy at the college is an upper-division course. Presumably, at least some upper-division students outside of the Industrial

1. What do you believe is the central ethical issue and how does the Engineering Code of Ethics apply here?
2. What are the key facts and/or perspectives on both sides of the situation?
3. What were the societal impacts that occurred due to decisions related to financial analysis?
4. Formulate and justify what you believe is the correct conclusion/position/action for the case.
5. Describe how your personal moral beliefs and intuitions were either in agreement or in conflict with the Engineering Code of Ethics or your final conclusion.

Figure 1 – Writing Assignment Guiding Questions

Engineering Technology program would not see financial analysis as a central part of their studies, but most students would be somewhat familiar with famous cases of engineering ethics (such as the Ford Pinto case). We believe this presented an opportunity to use this common ground to establish the importance of financial analysis as a component of engineering education, as well as facilitating the ethics lesson. Another rationale for the early delivery was that because much of the content in Engineering Economy involves mathematical concepts, introducing the module later in the course would seem out of place. A review of Engineering Economy textbooks reveals that this rationale was well-founded. Seven popular Engineering Economy textbooks [6, 11-16] were examined for inclusion of a section on ethics content, the nature of the content found in the section, and which chapter the content appeared. Three of the seven texts [6, 11, 14] included a dedicated ethics section, and in each instance these texts included references or discussions relating to moral principles, professional ethics, and the Code of Ethics for Engineers. Each of these three texts also included end-of-chapter questions regarding the application of ethics.

We tested this rationale for early introduction through an end-of-semester survey administered to each of the 19 students who participated in the initial survey. After briefly revisiting the assignment three weeks before the end of the semester, students were presented with a series of questions regarding the timing of ethics discussions during the semester (early, late, or continually). Responses were collected using a Likert-type scale (1 = Strongly Disagree, 2 = Disagree, 3 = Somewhat Disagree, 4 = Somewhat Agree, 5 = Agree, 6 = Strongly Agree). The questions and student responses are shown in Table 3, where Percent Agree represents the percentage of student who chose one of the three agree statements. The results suggest that

Table 3 – Survey Results on Timing of Module

Question	Percent Agree	Mean	SD
Introducing ethics early in Engineering Economics courses is beneficial because it sets the tone for the class regarding the importance of financial decisions that exist alongside those of my major discipline.	84%	4.26	1.15
Introducing ethics early in Engineering Economics courses is not beneficial because little is known about financial decision-making processes until later in the course.	33%	2.89	1.28
Continually discussing ethics in Engineering Economics courses is beneficial because it reinforces the importance of financial decisions in engineering practice.	74%	4.11	0.94
Continually discussing ethics in Engineering Economics courses is not beneficial because it takes away from time that should be spent learning more about financial decision-making.	21%	2.89	0.88
Introducing ethics later in Engineering Economics courses is beneficial because the ethical aspects of decision-making are only clear once foundational knowledge is obtained.	58%	3.37	1.42
Introducing ethics later in Engineering Economics courses is not beneficial because it makes ethics seem like an afterthought, when it is actually very important.	53%	3.63	1.12

students tend to believe that discussing ethics early or continually is more appropriate than discussing ethics later in the semester. In addition to the questions shown, students were asked to rank their preference for timing using a 1 to 3 scale, where 1 was the most preferred method and 3 the least. Similar to rationale-based questions, continually discussing ethics ($\mu = 1.74$) or discussing ethics early in the semester ($\mu = 1.95$) were preferred over discussing ethics later in the semester ($\mu = 2.37$).

Given the placement of ethics discussions in popular textbooks and the evidence from the surveys, it seems that administering the module early in the semester is a good choice. Additionally, the authors believe that examining the subject of financial analysis through the lens of ethics helps solidify the importance of the subject in the minds of students. We believe students who do not see the subject as important may be less likely to take the time to understand the techniques needed to make sound financial decisions and may be less likely to recognize misapplications of the techniques themselves. Mitigating either of these deficiencies would be valuable both for students and the engineering profession as a whole.

Module-based versus Micro-Insertion Approach

Another consideration for how to approach the integration of ethics into courses is whether to use a module-based approach like the one described here or a micro-insertion approach. The micro-insertion approach calls for multiple "mini-lessons" in ethics to be woven into other aspects of the course by rewriting engineering problems to include an ethical component [17]. This is a technique that ethics-minded faculty are probably accustomed to and would certainly fall under the classification of an integrative approach. Although this approach was not strictly followed in this case, it is discussed here to highlight the considerations that led to the selection of a module-based approach and to show that some of its principles are in fact central to the module's design.

The two main considerations for taking the module-based approach were to ensure easy deployment across the various delivery methods and locations of the college and to ensure that the reflective writing component was a prominent part of the work. The module is designed to be easily adopted by emphasizing instruction based on simple moral concepts and their relationship to ethics, the Code of Ethics for Engineers, low in-class time commitment, and the use of classroom discussions. The actual teaching materials for the module consist of a few PowerPoint slides, a list of case studies and reference materials, and a set of guiding questions. These materials can be readily converted for use in online learning environments and are also very simple for different instructors to customize as needed. Adoption of a module may also be simpler than a micro-insertion approach in that once the lesson is completed early in the semester, the topic does not necessarily have to be revisited again. We presume not all instructors will be interested in discussing ethics continually in an Engineering Economy course. Nevertheless, the module does retain the ability to be customized by individual instructors through the personalization of the case studies and guiding questions.

The other primary rationale for using a module-based approach was the emphasis on reflective writing. Continually addressing ethics through writing is probably not feasible in an Engineering Economy course in which most of the work is based on mathematics. Evaluating a single large

writing assignment is challenging enough, and evaluating many over the course of the semester would almost certainly be prohibitive. However, the ability to leverage technology in the evaluation of the writing assignment is built-in to the module. The learning management system used by the college features a built-in plagiarism checker and peer evaluation system, and these two systems can dramatically reduce the burden of evaluation for the writing component. The use of such systems allows instructors to maintain the focus on class discussions.

One last factor that contributed to the use of a module-based approach is the mathematical nature of the material. It was assumed that when teaching mathematical concepts, instructors will naturally gravitate toward using familiar examples and techniques in order to explain the material thoroughly. Approaching ethics using a micro-insertion approach would mean either relying on individual instructors to develop several of their own ethics-based problems, or prescribing problems for instructors to administer. Both of these options would likely be met with resistance from faculty and instructors, and the number of class sections and geographic locations compounds the problem significantly.

Case Studies

The last aspect of the module's design we reflect on here has to do with the selection and treatment of the case studies. Students are given wide latitude to select a case topic that is interesting to them, but this approach can present challenges when the ethical and financial aspects of the case are not clearly connected. This of course is not a problem in cases like the Ford Pinto, but connections may not be as clear in contemporary cases such as the Deepwater Horizon disaster. Freedom to choose an interesting case is an important part of the module's design, and other aspects of the module's design can help overcome this challenge. One such aspect is the discussion following Part 1 of the writing assignment, which gives students an opportunity to hear from their peers and the instructor before finalizing their thoughts. Another way the challenge is mitigated is by allowing the instructor preselect several cases and possibly provide some gentle direction on where student can look within the case to find ethical issues. As mentioned before, the preselected cases do not necessarily need to be formal case studies, but some form of guidance such as links to journal articles, newspaper articles, or editorials from trade publications are valuable places for students to begin their work. We believe that most students will choose a case from the preselected list (16 of 19 students selected cases from the predetermined list during the initial offering). One last note regarding the preselected list is that at least some of the cases should be refreshed or rotated frequently, possibly with contemporary cases to reinforce the idea that the issues explored are relevant today.

Another way this challenge of finding links between financial aspects can be handled is by allowing students to hypothesize about such relationships. When there are clear financial implications, students tend to subscribe to the theory that an overwhelming desire for profit maximization is the root of all unethical financial decisions, but in reality there may be better explanations. Both of the reference articles for the Ford Pinto case allude to factors other than greed that may have contributed to the decision to leave the design unchanged, making the case useful in this regard as well. Examples of factors that have been cited as sources of ethical failures in industry are fear, unrealistic goal setting, conflicting goals, and company culture [18, 19], and all of these can be approached from a financial perspective. We believe it is valuable

for students consider these factors in their writing. The discussion after Part 1 of the assignment is the best forum for the instructor to help students refine their thoughts about such (potential) factors, and like the surveys, this discussion can take place during class or online.

Discussion

From the outset, this module was always intended to be meaningful for students, easily tailored to the interests of different faculty, and flexible in its delivery and assessment. We believe the design of the module achieves these goals and can serve as a starting point for faculty wishing to include an ethics lesson in their Engineering Economy course. Professional ethics is too important of a subject to be relegated solely to dedicated engineering ethics courses, and faculty should not be hesitant to include ethics as a part of any engineering class. While some may feel teaching ethical or moral principles is beyond their expertise, we believe the micro-insertion method described in other works and the module-based approach described here are both viable options for teaching ethics. When using a module-based approach, we do believe it can be beneficial to link ethics to some other aspect of the class rather than simply adding the lesson on top or in place of other subjects, as was done here with the overall introduction to the course.

Our assessment is that the overall approach regarding timing, the two-part assignment, treatment of the cases, and the class discussions worked very well in the small classroom setting. We also believe that very few changes would be necessary to successfully implement the same basic strategy in large classroom or online environments. One simple change we plan on making relates to the artifact from Part 1 of the writing assignment. In the future this will change to be a list of takeaways for all three cases instead of the short written summary of only one case. One obvious reason for this change is to help ensure that all of the cases were indeed considered, but more importantly because after writing just one or two paragraphs about a case students are likely to feel invested in that particular aspect of the case and may be less likely to change their viewpoint. This would defeat the purpose of the interim discussion. We expect that the timing of the module and the informal treatment of case studies, including allowing students to hypothesize on the links between ethical and financial components, are aspects that will remain unchanged. However, because any hypothesized links should be well-founded we do anticipate addressing more specifically in class what a “reasonable” link might look like. This is probably best accomplished by discussing some of the ways ethical breakdowns happen [19].

A resource that may be necessary for successful implementation of the module is some form of training for how to approach classroom discussions and how to confidently identify the ethical dimensions of case studies that are interesting to them. Recommending cases is a meaningful way the module can be tailored to suit individual instructors and classroom situations, and the freedom to hypothesize about ethical dimensions widens the scope of cases that can be explored from a financial perspective. This freedom to hypothesize on the ethical dimensions mirrors what is done when writing micro-insertion problems, and Riley et al [17] describes training that emphasizes the examination of a relevant code of ethics, reflecting on practical experience, asking practitioners about issues that arise in their work, reviewing non-peer reviewed written works pertaining to individual engineering disciplines, or by simply talking with students. Again, the constraint here is that hypothetical situations should be reasonable, so providing some form of training via published works is appropriate.

The main consideration for large classrooms or large online class sections is likely to be grading support for written portion of the work. Further implementation of the module at the college will make use of the Gradient peer review technology that is available at Purdue. Using a Calibrated Peer Review process [20, 21], the system automates calibrations for writing quality and content, assigns papers to reviewers, and facilitates the feedback process. For large classes, this can greatly reduce or eliminate the burden of evaluating large number of lengthy papers that in reality may be quite different from one another in several ways. Several online systems exist to facilitate peer review, although many are likely to be cost prohibitive unless they are provided by the institution. In such cases, faculty should feel free to adapt the writing assignment into some other form of artifact that best suits their individual needs. The primary reason a writing assignment was used in this case was that the inclusion of writing assignments in technical courses is a stated goal of the institution [22], and use of calibrated peer review as a tool to facilitate the integration of humanities in engineering technology curricula is an active area of exploration at the college.

Designing this module while keeping the goal of broad implementation across the college in mind has also resulted in some general questions about how ethics may be approached in Engineering Economy courses at other institutions. Our general assumption is that the subject of ethics is probably addressed in some fashion in many classrooms, but that it is probably not a significant part of the course in terms of time spent or proportion of the course grade. What is less clear but may be valuable to know is how faculty view the teaching ethics alongside financial analysis, how they approach the subject when it is taught, what factors could influence them to include a writing component, how they view the somewhat casual treatment of ethics as described here and by Riley et al [17], and how confident they are about teaching ethics. Understanding these facets of Engineering Economy instruction for the purposes of compiling a set of best practices for ethics instruction would be a benefit to all who teach Engineering Economy. We believe any research along these lines should be grounded in the fields of Management and Ethics as well as Engineering.

References

1. Humanities Indicators. (2017). *Bachelor's Degrees in the Humanities*. Retrieved from https://humanitiesindicators.org/content/indicatordoc.aspx?i=34.
2. The Editors, (2016), "STEM Education is vital – but not at the expense of the humanities," Scientific American, Retrieved from https://www.scientificamerican.com/article/stem-education-is-vital-but-not-at-the-expense-of-the-humanities/.
3. Ottino, J. M., & Gary, S. M. (2016). "Building a bridge between engineering and the humanities". *The Chronicle of Higher Education*, February, 14, 2016. [Online]. Available: https://www.chronicle.com/article/Building-a-Bridge-Between/235305.
4. Bucciarelli, L.L., Drew, D.E., (2015). "Liberal studies in engineering – a design plan, *Engineering Studies* 7(2-3), 103-122.
5. Culver, S.M., Puri, I.K., Wokutch, R.E., Lohani, V., (2013), "Comparison of engagement with ethics between an engineering and a business program," *Science and Engineering Ethics*, 19, 585-597.

6. Blank, L.T., Tarquin, A.J., (2018), *Engineering economy* (8th), New York, NY: McGraw-Hill Education.
7. Harris, C.E., Pritchard, M.S., Rabins, M.J., (2004), *Engineering ethics: Concepts and cases* (3rd), Belmont, CA: Wadsworth, Cengage Learning.
8. National Society of Professional Engineers. (2007). *Code of Ethics for Engineers*. Retrieved from https://www.nspe.org/sites/default/files/resources/pdfs/Ethics/CodeofEthics/Code-2007-July.pdf.
9. Case: The Ford Pinto. [Online]. Available: https://philosophia.uncg.edu/phi361-matteson/module-1-why-does-business-need-ethics/case-the-ford-pinto/.
10. Schwartz, G.T., (1991), "The myth of the Ford Pinto case," *Rutgers Law Review*, 43, 1013-1035. [Online]. Available: http://www.pointoflaw.com/articles/The_Myth_of_the_Ford_Pinto_Case.pdf/.
11. Blank, L.T., Tarquin, A.J., (2014), *Basics of engineering economy* (2nd), New York, NY: McGraw-Hill.
12. Park, C.S., (2016), *Contemporary engineering economics* (6th), Hoboken, NJ: Pearson.
13. Sullivan, W.G., Wicks, E.M., Koelling, C.P., (2015), *Engineering economy* (16th), Upper Saddle River, NJ: Pearson Higher Education.
14. Newnan, D.G., Eschenbach, T.G., Lavelle, J.P., Lewis, N.A., (2017), *Engineering economic analysis* (13th), New York, NY: Oxford University Press.
15. White, J.A., Case, K.E., Pratt, D.B., (2010), *Principles of engineering economic analysis* (5th), Hoboken, NJ: John Wiley & Sons.
16. White, J.A., Grasman, K.S., Case, K.E., Needy, K.L., Pratt, D.B., (2013), *Fundamentals of engineering economic analysis*, Hoboken, NJ: John Wiley & Sons.
17. Riley, K., Davis, M., Jackson, A.C., Maciukenas, J., (2009), "Ethics in the details: Communicating engineering ethics via micro-insertion," *IEEE Transactions on Professional Communication*, 52(1), 95-108.
18. Bazerman, M.H., Tenbrunsel, A.E., (2011), "Ethical Breakdowns," *Harvard Business Review*. [Online]. Available: https://hbr.org/2011/04/ethical-breakdowns.
19. Carucci, R., (2016), "Why ethical people make unethical choices," *Harvard Business Review*. [Online]. Available: https://hbr.org/2016/12/why-ethical-people-make-unethical-choices.
20. Purdue Gradient, https://www.itap.purdue.edu/learning/tools/gradient.html.
21. Ruggiero, D., Harbor, J., (2013), "Using writing assignments with calibrated peer review to increase engagement and improve learning in an undergraduate environmental science course," *International Journal for the Scholarship of Teaching and Learning* 7(2).
22. Purdue Polytechnic Integrated Humanities, https://polytechnic.purdue.edu/answering-the-call/integrated-humanities-studies/.

Appendix A

		Course Responses			Culver et al.		
	Statement	Percent Agree	Mean	*SD*	Percent Agree	Mean	*SD*
S1	In my curriculum, there has been a substantial emphasis on teaching ethics.	95%	4.74	1.05	72%	4.06	1.32
S2	In my classes, I have often had the opportunity to initiate discussions regarding ethical issues.	89%	4.32	1.00	38%	3.08	1.31
S3	My professors have often expressed concern over ethical issues in applied settings.	89%	4.67	0.97	58%	3.67	1.32
S4	Ethical concerns do not apply to most of us in engineering because engineering is separate from society.	0%	1.42	0.51	12%	2.06	1.09
S5	If an engineering practice is legal, then it is also necessarily ethical.	29%	2.97	1.57	18%	2.31	1.32
S6	In general, ethics is independent of the country or culture in which it occurs.	21%	2.84	1.42	41%	3.19	1.48
S7	Professional ethics and personal ethics are two separate things.	63%	3.68	1.25	44%	3.19	1.45
S8	Ethics do not vary from situation to situation.	47%	3.53	1.58	30%	2.92	1.42
S9	Ethical issues do not pertain to technological advances.	5%	1.79	1.08	8%	1.99	0.84
S10	Ethics is too complicated and cannot be taught.	5%	1.71	0.87	12%	2.11	1.16
S11	An engineer's ethical obligations do not include financial aspects or making recommendations with financial implications.	5%	1.68	0.82			
S12	As an employee or public servant, it is an ethical responsibility of mine to maximize financial benefits or minimize financial costs.	89%	4.37	1.07			
S13	Ethical questions are usually easy to resolve if individuals act with others' best interests in mind.	68%	4.00	1.37			