Using a Phenomenological Approach to Teach Engineering Ethics in a First-year Engineering Course

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Abstract

At Michigan Technological University, a phenomenological approach has been used to teach engineering ethics in a one-credit semester long course taken primarily by 3rd and 4th year students for the past three years. In this course students examine what it is to be an ethical engineer through a series of readings about ethical engineers, personal interviews with engineers, and their personal reflection about their own character and values. From these experiences, students begin to encounter the “essence” of an ethical engineer. They were asked to experience, as much as possible in a classroom setting, the phenomenon of being an ethical engineer. Pre- and post-test results of the Defining Issues Test-2 (DIT-2, a validated and nationally used test of ethical reasoning developed by the Office for the Study of Ethical Development at the University of Alabama) indicate that students in this course improved their ethical reasoning by 23% (N2 scale) and by 18.8% (P scale).

Engineering Ethics is a topic that is covered in the common First-Year Engineering courses at Michigan Tech. In the past, this topic has been approached through the analyses of case studies using prescribed strategies to solve an ethical dilemma. A new ethics module has been developed that uses a modification of the phenomenological approach described above. A pilot test will be used to compare our current ethics analysis method and the phenomenological approach. Both approaches will be evaluated using pre- and post-tests of the DIT-2. If the pilot course results are confirmed, a phenomenological approach to teaching engineering ethics may become standard, not only for first-year engineering students taking Engineering Fundamentals at Michigan Tech, but for students at all levels in all engineering fields.

Introduction

Since the adoption of ABET’s (Accreditation Board for Engineering and Technology, Inc.) Engineering Criterion 3(f), which requires that engineering graduates must have “an understanding of professional and ethical responsibility,” engineering education scholarship has included a stronger focus on engineering ethics education. Increasingly, however, two concerns dominate the discussion in engineering ethics pedagogy and, together, pose a conundrum for ethics educators: 21st century technologies raise daunting ethical questions that require a strong engagement with ethics by engineers; yet engineering students still don’t care much about studying ethics[1]. Most ethics education researchers agree that these concerns are not being adequately addressed by current ethics pedagogical practice.[1-3] There is widespread agreement that engineering ethics involves much more than applying rules and problem-solving models to case studies[4-6] and that engineering students should actually care about being ethical engineers. But there is much less agreement about how to achieve that outcome. Our work in engineering ethics education suggests that phenomenology, which is the study of the essences of experiences,

[1] One of the authors teaches an elective, 3000-level, 1-credit, Ethics in Engineering Design course. A survey taken of students each term by the instructor reveals that, with a rare exception, the students take this course because they need one credit to graduate and not because they have affirmatively chosen to study ethics.
can be used as a pedagogical method for undergraduate students to explore the essences of what it is to be an ethical engineer in the real world of everyday engineering practice.

Bucciarelli argues that students need to understand the complex world of the engineer beyond the technical aspects of design work. Lynch and Kline contend that engineering students need to experience ethics in the “real world” rather than through studying abstract notions of codes and moral theories. Phenomenology is a particularly useful approach to study real world professional experience. Sadala and Adorno, who used phenomenology to help nursing students understand the world of nursing on an isolation ward, write that this method is the most appropriate way to investigate the lived professional world because students will acquire “experience in a situation where they relate to an already given world, which is out there, into which they are launched and which they will have necessarily to face” (emphasis added). Applying this approach to engineering, we asked whether we could have our students investigate the world of ethical engineering practice by asking the phenomenological question: “What is it to be an ethical engineer?”

Phenomenology as a pedagogical method for engineering ethics education is not entirely untried or unreported. Porra, a professor at the Helsinki University of Technology in Finland, described a phenomenological approach to ethics in design engineering at the 2004 International Conference on Engineering Education and Research. He introduced phenomenological methods in an existing course to help reveal to students the values, forces, interests, and mechanisms in society that pose ethical questions for design engineers. Broome described an impromptu activity he tried in an ethics workshop to prepare students for the FEE (Fundamentals of Engineering Exam) professional engineering licensing exam. He asked students to take the exam before he delivered his lecture. Then, also before the students received any instruction, Broome asked them to take the exam again but, this time, to imagine themselves as an “aged, highly mature person: a family member or some legendary character; someone who exhibited great wisdom and caring for others.” The results were stunning: students either failed or performed marginally on the first exam but “maximized the examination” when they imagined themselves to be wise and caring. Wike, who adopts a values-based approach to teaching engineering ethics, describes values in decidedly phenomenological terms: “If, as I am claiming, the best way to talk about ethics is in terms of values, then ethics is everywhere. Ethics isn’t ‘outside’ a technical practice; it is already there. We just have to make it explicit” (emphasis added). Lynch and Kline closely describe a phenomenological approach to engineering ethics when they suggest that students focus on the everyday mundane ordinariness – the essences – of engineering ethical decision-making. These are all attempts to get students to understand – to experience, describe, and empathize with – the real world phenomenon of being an ethical engineer.

Phenomenological Approach in an Upper Division Course
We first used a phenomenological approach to engineering ethics instruction in a 3000-level, one-credit, elective, semester-long course taken by third and fourth year undergraduate engineering students. The instructor had taught this course for several years with results that were consistent with those observed by others.
The teaching approach adheres to the underlying principles of phenomenological inquiry. First, the question: “what is it to be an ethical engineer?” does not have a pre-known answer and no theory is put forth for students to test. Instead, inquiry is a subjective rather than objective experience in which each student explores the phenomenon and discovers his or her own answer to the question. Second, the focus is on real engineers, real-world engineering practice, the everyday impact and operation of personal and professional values, and the “everydayness” of engineering work and ethical practice. Research confirms that undergraduate engineers develop a sense of their ethical professional identity far more from contact with other engineers than from formal study of engineering ethics. Third, because there are no fixed answers, ambiguity is expected and necessary. Becoming comfortable with ambiguity in a profession that rejects that notion is part of the inquiry process. Finally, this is an inductive rather than deductive process; questioning, reflection and interpretation are the tools of discovery and learning.

There were two course instructional approaches: first, students would develop a working knowledge of the principles of ethical theory and how these theories connect to actual personal and professional ethical decision making and, second, students would explore and articulate their own understanding of what it is to be an ethical engineer, the question that will be their central inquiry during the semester. The students undertake a variety of assignments informed by phenomenology and designed to help them discover, interpret, and describe the real, every day, lived experiences of an ethical engineer. Assignments include several readings (currently, 14 readings covering, for example comparative perspectives on engineering ethics by culture and multiple readings regarding aspects of ethics and technology such as artificial intelligence, sustainability), interviews of practicing engineers (each student must conduct at least one interview), multiple activities in which students explore and reflect on personal and professional values in a variety of contexts (these include in-class discussions and writing assignments), engineering and technology research from ethical perspectives, two individual meetings with the instructor (added to curriculum in 2014 class, a change that received strong student support and will be retained in future classes), and a final research paper/essay in which the students address the question, based on all their investigations and activities during the semester: what is it to be an ethical engineer?. It’s important to note that this phenomenological approach is intended to supplement rather than to supplant traditional engineering ethics. Ethical theory – which includes the predominant theories of rules-based ethics and utilitarianism or consequentialism – is studied both as theory and in the applied contexts of the NSPE (National Society of Professional Engineers) Code of Ethics and cost-benefit and related decision analyses models. But the emphasis of inquiry is on exploring, identifying, and understanding the values that inform all real world professional and personal ethical decisions. The course is intended to help achieve two student learning outcomes: (1) better ethical reasoning skills and (2) a deeper understanding of professional and ethical responsibility along with a stronger commitment to being ethical engineers.

The course has been taught using this method for three terms. Two assessment methods were selected to help measure the intended learning outcomes. The Defining Issues Test-2 (DIT-2) was used to measure improvements in ethical reasoning. It was administered as a pre-test during the first week of the semester and a post-test at the end of week 14 of the semester. The DIT-2 is a test of ethical reasoning developed by researchers in the Center for the Study of Ethical Development. It is a multiple choice test that consists of a set of five (non-engineering) scenarios
presenting various ethical dilemmas without obviously right answers. The DIT-2 gives two principal scores, the P score and the N2 score, which quantitatively measure the participants’ ethical or moral reasoning skills.\textsuperscript{15} The DIT (forerunner to DIT-2) and DIT-2 have their critics.\textsuperscript{16-18} However, although alternatives to the DIT-2 are being developed and tested,\textsuperscript{2} the DIT and the DIT-2 continue to be used extensively by researchers to measure the ethical reasoning skills of undergraduate engineering students\textsuperscript{20} and the effectiveness of engineering ethics instruction.\textsuperscript{21-22}

Measurement of ethical commitment or engagement is more challenging. Research into the development of tests to measure ethical outcomes for undergraduate engineering students is almost entirely centered on the quantitative measurement of ethical reasoning skills. There is growing attention paid to measurement of ethical sensitivity but there has been no method developed for the measurement of ethical commitment or engagement that has been tested and disseminated for widespread use. For this project, the final paper written by students that answered the question, “What is it to be an ethical engineer?” was used for qualitative assessment of ethical commitment/engagement. Essays were examined for the development of themes that would evidence such ethical commitment/engagement.

Table 1 shows the DIT-2 pre-and post-test results (P score and N2 score\textsuperscript{3}) for students in each of the three terms during which the phenomenological curriculum was used. The scores of students taking this course are compared to the results the National Science Foundation-funded SEED project (an unrelated study that sought to measure the ethical knowledge, reasoning, and behavior of undergraduate engineering students)\textsuperscript{4}, and the DIT-2 national norms for college-aged students. Using the DIT-2 as a measure of ethical reasoning, mean N2 and P scores of students in the phenomenology-centered engineering ethics course improved significantly in each of the three years. For example, in 2011, N2 scores increased from 28.59 pre-test to 35.29 post-test, a 23% increase. Mean P scores for these students increased from 30.10 pre-test to 35.75 post-test, an increase of nearly 19%. Improvements of 21% and 27% were observed for students in the one-credit class during 2013 and 2014, respectively. These changes are important in several respects:

1. First, even though the students in the ethics course were mostly students in their final year of undergraduate engineering studies, their pre-test ethical reasoning skills were very

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\textsuperscript{2} For example, J. Borenstein, et al. have developed the Engineering and Science Issues Test (ESIT) that uses job-related ethical dilemmas from science and engineering, rather than the non-engineering-specific dilemmas of the DIT-2, to measure moral judgment.\textsuperscript{19}

\textsuperscript{3} The P and N2 scores are part of the moral development indices developed for the DIT-2. They are part of a 6-stage moral development schema developed by Rest, et al.\textsuperscript{15,23} and signify higher levels of moral development (stages 5 and 6). The P score was initially developed for the original DIT. The N2 score was developed for the DIT-2, although P scores continue to be provided. The N2 score, in the opinion of Bebeau & Thoma\textsuperscript{23}, is a better indicator of moral development skills. See the \textit{Guide for DIT-2} for in-depth explanations of the various scoring schema.\textsuperscript{23}

\textsuperscript{4} The Survey of Engineering Ethical Development (SEED) project was a multi-year project funded by the National Science Foundation and headed by Principal Investigators from Lawrence Technological University, California Polytechnic State University, and the University of Michigan. This was the first research project to conduct a nationwide assessment of the ethical development (ethical knowledge, reasoning, and behavior) of undergraduate engineering students. A total of over 4,000 undergraduate engineering students from 18 institutions, including Michigan Tech, participated in the SEED survey. The DIT-2 was used to measure ethical reasoning skills. The study was intended to measure student ethical development across all undergraduate years and does not differentiate by the level or degree of ethical education students have received. In this respect, the SEED study offers a broad snapshot of the current ethical development of U.S. undergraduate engineering students at the 18 tested institutions. Results from the study were disseminated in 2011.
close to the mean ethical reasoning scores of all the engineering students from Michigan Tech who participated in the SEED study. We must recall that the SEED study included all levels of undergraduate students, so students at Michigan Tech do not seem to improve their ethical reasoning skills as they progress during their undergraduate years. The fact that a 1-credit ethics course could help them improve their ethical reasoning skills so dramatically over 14 weeks is an outcome that deserves attention. It speaks, first, to the impact of an ethics course and, second, to the potential impact of an ethics course that uses a phenomenological approach. This outcome alone suggests that students need not commit to a 3-credit ethics course for significant improvements in a fundamental skill of ethical reasoning.

2. The improved post-test scores of students in the ethics course were higher than the mean N2 and P scores of students from all other 17 institutions who participated in the SEED project. The scores of students from Michigan Tech who participated in the SEED study were significantly lower than their peers from the other 17 institutions. However, students in the pilot ethics course were able to come from those below-average scores and demonstrate improved ethical reasoning with scores that were significantly higher than their peers. This also speaks to the value of a 1-credit ethics course.

3. Finally, the students in the ethics course ended up with post-test P and N2 scores that align with the national norms for college-aged students in all majors, not just engineering. This is important because the common wisdom is that engineering students have less empathy than do non-engineering students and that they somehow do not “think the same” as students in other majors. The outcome from the pilot course demonstrates that engineering students can achieve the same levels of ethical reasoning as all college-aged students, regardless of major.

<table>
<thead>
<tr>
<th>DIT-2 Score</th>
<th>ENT 3958</th>
<th>NSF SEED Project</th>
<th>DIT-2 National Norms for College-Aged Students</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2011</td>
<td>2013</td>
<td>2014</td>
</tr>
<tr>
<td>Pre-test</td>
<td>Post-test</td>
<td>Pre-test</td>
<td>Post-test</td>
</tr>
<tr>
<td>(n=20)</td>
<td>(n=16)</td>
<td>(n=20)</td>
<td>(n=17)</td>
</tr>
<tr>
<td>P Score</td>
<td>30.1</td>
<td>35.75</td>
<td>26.10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N2 Score</td>
<td>28.59</td>
<td>35.28</td>
<td>26.82</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

We are reluctant to claim that the phenomenological approach is the cause for these improvements in ethical reasoning. First, the improvements in the pre and post tests are statistically significant only for the 2014 class (p<.05). In part this is owing to the large standard deviations for all participants who take the DIT-2, which makes achieving statistical significance more difficult. Large standard deviations are present for our data as well as for the national norms of the DIT-2. That said, the student scores from each year consistently rise and do not fall.
Second, the number of students in the phenomenology-focused ethics course each year is small. Third, there was no control group of students who studied ethics using a traditional engineering ethics curriculum and who were tested and no control group of students who took no ethics course at all and who were tested (the SEED study cannot serve as such a control because there was no control for ethics instruction, if any, that students had received). Research by others concerning the impact of ethics coursework on ethical reasoning skills (measured by the DIT) based on traditional ethics instruction methods show inconsistent results (SEED Study). However, because of the small number of students who enroll in this elective ethics course (offered only once per year), it has not been practical to establish a control group. This clearly remains an area that needs to be explored. Based on outcomes and potential implications, however, there is good reason to think that there might be a causal effect and that our investigation should proceed.

Ethics Modules in First-Year Engineering Courses
The results from this phenomenological approach to teaching engineering ethics in an upper division course were encouraging enough to pilot the approach in the first year Engineering Fundamentals program at Michigan Tech.

Michigan Tech has a common first-year program, with two pathways based on math placement. Students who are calculus ready (placed in calculus 1 or higher) take a two course sequence: ENG1101 – Engineering Analysis and Problem Solving (3 credits), followed by ENG1102 – Engineering Modeling and Design (3 credits). Students that begin in pre-calculus students take a three semester sequence: ENG1001 – Engineering Problem Solving (2 credits), ENG1100 – Engineering Analysis (2 credits) and ENG1102 – Engineering Modeling and Design (3 credits). The phenomenological approach was piloted in Fall 2013 in one of four sections of ENG1001 (students in pre-calculus) and four of thirteen sections of ENG1101 (students also calculus I or higher). In this study we compare the pilot sections to three sections of ENG1001 and five sections of ENG1101 which cover ethics through case studies analysis.

The traditional version of ethics in the first-year engineering courses involves developing and using a strategy to make ethical decisions on the job. The reading includes chapters 1, 2, and 6 of Engineering Ethics by Fleddermann. The coverage in class begins with a discussion of the basic terminology and motivations in regards to engineering ethics. This includes addressing the difference between ethics and engineering ethics, reviewing codes of ethics including the NSPE code of ethics, and defining terms involved in ethical decision making such as whistleblowing, client confidentiality, negligence, and conflict of interest. In discussing the motivation for ethics, instructors push their students to determine the difference between their personal morals and engineering ethics. Students are made aware of their responsibility of being an ethical engineer, why this is required, why this is important, and how to approach life on the job as an ethical engineer. Some instructors include some sociological information that is included in the phenomenological approach, although this is not common practice.

Next, the students are presented with the practical aspect of an ethical dilemma, and tools are developed to help make ethical decisions. Simple tests are discussed first, including the golden rule, basic values tests, and personal versus greater costs. This culminated in the implementation of the RESOLVEDD Strategy which is used to make ethical decisions when the issues are very
complex and there is not one clear-cut “right” answer. The RESOLVEDD Strategy of making ethical decisions included the following steps:

R: Review the history, background, and details of the case.
E1: State the main ethical problem or issue present in the case.
S: List the main possible solutions to the case.
O: State the important and probable outcomes or consequences of each main solution.
L: Describe the likely impact of each main solution on people's lives.
V: Explain the values upheld and those violated by each main solution.
E2: Evaluate each main solution and its outcomes, likely impact, and the values upheld and violated by it. Compare the possible solutions to each other and weigh them.
D1: Decide which solution is the best; state it, clarify its details, and justify it.
D2: Defend the decision against objections to its main weaknesses.

Students then use the RESOLVEDD Strategy to analyze various engineering case studies. They work with other students in the class to analyze the cases and then discuss these cases, their outcomes, and the ethical values upheld and violated. This allows students to see how a decision can be made by applying ethical values in real-world engineering situations.

Instructors in the course bring in their personal experience with ethics on the job in order to help students better understand the complexity of ethical decision making. Certain instructors also talk about business and engineering ethics including where they intersect, where they differ, and how to best approach ethical decision-making as an engineer working for a corporation. It is also important to note that some instructors tie this ethics discussion intimately with their sustainability lessons which occur later in the semester.

As homework, students are asked to discuss a case study using their understanding of engineering ethics garnered from the course lessons (which could include use of the RESOLVEDD Strategy). This is done by writing a short essay individually. Students are graded on their ability to coalesce the information and think critically as opposed to being “right” or “wrong.”

The phenomenological version of ethics was modeled after the upper division course described earlier, focusing on what it means to be an ethical engineer. Reading for this pilot group included articles by Bunge,27 Schrader-Frachette,28 and Badaracco.29 Each of these were discussed individually during class. Coverage in-class began by discussing the importance of ethics in engineering, the basis for how we form ethical values and make decisions (personal values, rights-and-responsibility (rules) based, outcome (utilitarian) based), and problems that arise with both rules-based and outcomes-based decision making (Inquiring murderer and Ivan's challenge examples). Students also attended a session where a panel of engineering professionals discussed the question: what is it to be an ethical engineer?

As homework, student teams were to prepare a video that discusses and attempts to resolve ethical issues for a technology chosen by the team, using the four questions posed by Badaracco. Each student then reviewed and evaluated three videos prepared by other teams. The culminating ethics assignment was an individual essay where students answered the following
question, “Using what I have studied and learned about engineering ethics, what does it mean to me to be an ethical engineer?  

The traditional and phenomenological approaches devote four 1.5 hour class periods to ethics with an additional one to two class periods devoted to sustainability. However, students were engaged with their ethics and sustainability assignments over a period of three weeks for the traditional approach and up to four weeks for the phenomenological approach.

Results and Discussion

In order to compare our results with the SEED study and with the 1 credit upper division ethics course, students in our first-year engineering courses completed the DIT-2 test as pre- and post-tests in fall 2013. The pre-tests were completed immediately before ethics instruction began and the post tests were completed five weeks later, after completing all work associated with the ethics module. Unfortunately, we did not collect identifying information on our students so our results are general to the population of students instead of linked with individual students.

Table 2 below shows the differences in DIT-2 scores between the traditional ethics coverage and the phenomenological method in ENG1001 (students in pre-calculus). After running a two-tailed t-test, several results stood out. First, when comparing the pre-test results from both groups, there was no significant difference in scores. This is also true when comparing the pre- and post-tests of the traditional ethics coverage for this group of students. However, when looking at the difference between the pre- and post-tests in the phenomenological ethics coverage group, there was a statistically significant change in the personal interest measure (p<0.05) in the negative direction, indicating movement toward a higher level of moral development (i.e., less interest focused on one’s self after completing this method, personal interest being a lower level of moral development). The overall N2 score approaches significance (p=0.051) with a higher value on this measure. This may become significant with a larger sample. This suggests that for this group of students, the phenomenological approach shows a slight improvement in ethical reasoning, and a decrease in student personal interest, which is consistent with movement to higher levels of moral development.

Table 2. Comparison of Phenomenological and Traditional Ethics Coverage in ENG1001

<table>
<thead>
<tr>
<th>DIT-2 Measure</th>
<th>Traditional</th>
<th>Phenomenological</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre (N=111)</td>
<td>Post (N=66)</td>
<td>Pre (N=37)</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>Std. Dev</td>
<td>Mean</td>
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<tr>
<td>Personal_Interest</td>
<td>33.9</td>
<td>13.9</td>
<td>31.7</td>
</tr>
<tr>
<td>Maintains_Norms</td>
<td>33.1</td>
<td>12.7</td>
<td>32.8</td>
</tr>
<tr>
<td>P_Score</td>
<td>26.5</td>
<td>14.2</td>
<td>27.2</td>
</tr>
<tr>
<td>N2_Score</td>
<td>24.4</td>
<td>13.8</td>
<td>28.3</td>
</tr>
</tbody>
</table>

The t-tests were also run on the pre- and post-test results from students in ENG1101 (students in calculus I or higher) and the results were surprising as shown in Table 3. As with the ENG1001 course.
students, there was no statistical difference in pre-test scores between the different groups. The traditional method showed a decrease in personal interest (p<0.05), and an increase in the N2 score (p<0.05). The phenomenological method showed decreases in personal interest, maintains norms, and P value (p<0.001). Comparing the two results showed that there was a statistically significant difference between the post scores of the two methods. The personal interest, maintains norms, and P score all were statistically higher (p<0.001) in the traditional method. The N2 score was significant to p<0.05 toward the traditional method. For these students, it seems that the traditional method is more effective at improving ethical reasoning.

Table 3. Comparison of Phenomenological and Traditional Ethics Coverage in ENG1101

<table>
<thead>
<tr>
<th>DIT-2 Measure</th>
<th>Traditional</th>
<th>Phenomenological</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre (N=249) Post (N=178)</td>
<td>Pre (N=169) Post (N=146)</td>
</tr>
<tr>
<td></td>
<td>Mean Std. Dev Mean Std. Dev</td>
<td>Mean Std. Dev Mean Std. Dev</td>
</tr>
<tr>
<td>Personal_Interest</td>
<td>30.8 12.5 28.1 12.0</td>
<td>31.8 12.9 22.2 11.3</td>
</tr>
<tr>
<td>Maintains_Norms</td>
<td>31.6 13.3 31.5 12.7</td>
<td>32.8 12.8 27.4 10.8</td>
</tr>
<tr>
<td>P_Score</td>
<td>29.8 14.0 31.9 14.8</td>
<td>28.8 14.0 24.7 13.1</td>
</tr>
<tr>
<td>N2_Score</td>
<td>28.8 13.7 32.1 14.5</td>
<td>28.5 14.3 28.5 15.0</td>
</tr>
</tbody>
</table>

The improvements in ethical reasoning observed in the first-year engineering courses (Tables 2 and 3) are much smaller than the improvements observed in the upper division course (Table 1). This is likely due to the shorter amount of time devoted to ethics in the first-year course. Drake et al, suggest that to improve a student’s moral reasoning, ethics education must be more extensive than an engineering course that includes an ethics module.21

Looking at Figures 1 and 2 below, we have compared the performance of Michigan Tech students on the DIT-2 test as they progress through their degree program as compared to the national norms for the DIT-2 test.22 The freshman points represent the ENG1101 pre- and post-test results for our traditional method while the senior points represent the average of the pre- and post-test results from the 1 credit ethics course for which we have data. This data seems to indicate a few things. First, nationally there is not much growth between freshman and sophomore students and after that, there appears to be an exponential increase in results. It may also be that, while students have exposure to engineering ethics in their first year, the coursework in the sophomore level does not lend itself to ethical inquiry so this material is pushed off toward their upper-division courses. Within our university, we are lower than national norms, although it does appear that both the one-credit ethics course and the first-year ethics coverage can bring our students up to or exceeding national levels on this ethics measure. However, it does not look like the change shown in the first-year is retained to the senior year.
Since Figure 1 and Figure 2 show an increase in national results with educational level, we thought we might see a difference in our ENG1001 and ENG1101 students as they come to the university with a different level of preparedness (Pre-calculus vs. Calculus ready). Running an independent t-test on the pre-test results for these students does indicate that there is a statistically significant difference in overall N2 and P scores (p<0.05) as they enter the university. With this information, it seems that it would benefit us to look at the overall profile of our students by math level or other demographic information and see what factors contribute the most to these scores. In addition, tracking individual students through the program and monitoring their changes in ethical sensitivity and reasoning would be a good way to determine what factors impact their ethical awareness.

Conclusions and Future Directions
A phenomenological approach to teaching ethics has been very successful in a one-credit upper-division elective course at improving ethical reasoning as measured by the DIT-2. This approach was piloted in the first-year engineering courses in Fall 2013 and compared to the traditional ethics coverage using case study analysis, with mixed results. For students beginning in pre-calculus, it appears that the phenomenological approach slightly improves students’ ethical reasoning while decreasing their personal interest. The increase in ethical reasoning was approaching statistical significance, while the decrease in personal interest was statistically significant. The decrease in personal interest, having less focus on one’s self, is a positive result, and indicates movement to a higher level of moral development. For the calculus ready students, it appears the more traditional analysis of case studies improves students’ ethical reasoning, again while decreasing their personal interest. While the improvements in ethical reasoning in the first-year engineering courses are much smaller than those observed in the upper-division course, they are encouraging. Additionally, there is a statistically significant difference between the students that are calculus ready and those that are not. This difference will be examined further in future work. Also, we plan to collect identifying information so that we can track changes in an individual’s ethical reasoning and sensitivity.
References


