ETHICS ACROSS THE GRADUATE ENGINEERING CURRICULUM: AN EXPERIMENT IN TEACHING AND ASSESSMENT

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We now have three major approaches to ethics education in engineering, science, and similar professional programs: (1) free-standing courses in ethics; (2) modules, that is, large-scale insertions of ethics instruction into technical courses (for example, an hour-long discussion of conflict of interest or screening a pedagogical movie such as Incident at Morales); and (3) micro-insertions, that is, small-scale insertions of ethics instruction into technical courses, resulting in a dozen or so “ethics mini-lessons” during a semester, each lasting only a few minutes. What we describe here is an experiment in the application of micro-insertion to graduate students in engineering. Though it is now only “a work in progress,” it is already interesting both for what it has achieved and for the central problem of assessment it has yet to solve. We hope it will suggest other projects both for introducing ethics across the curriculum and for evaluating what has been achieved. We are also hoping for help with that central problem.

1. INTRODUCTION

There is some evidence that both free-standing courses and modules can improve moral judgment and the grasp of “intermediate ethical concepts” such as data integrity, duty to the public, and so on. However, much of this evidence derives from the study of dental students. Much of the remainder, evidence more closely related to graduate education of engineers, is concerned mostly with students and faculty in the biomedical sciences. Nothing has so far been published on the effectiveness of various ways of teaching ethics to graduate students in engineering. Indeed, even published work on the effectiveness of teaching ethics to undergraduates in engineering is rare, a surprise given that engineering’s main accrediting agency (ABET) has—for more than a decade—been pressing
engineering schools to include ethics in their curricula.\(^2\) Several of us—at IIT’s Center for the Study of Ethics in the Professions (CSEP) or the Humanities Department—therefore decided to undertake a study of the micro-insertion approach in graduate education of engineers. We proposed a three-year, three-campus study to the National Science Foundation (NSF). The proposal was funded in September 2006.\(^3\) We began work immediately.

Because labs are central to graduate education in engineering, science, and similar fields, part of what we proposed was to compare the effectiveness of micro-insertion in the classroom with micro-insertion in the lab. We used a nanotechnology lab because we thought that the students’ engagement with practical projects in an emerging technology should provide illuminatingly new micro-insertion problems, useful questions related to them, and useful insights.

Although research exists about the effectiveness of free-standing courses and modules in ethics instruction at the graduate level for the first two approaches (free-standing courses and modules), \textit{no research exists as yet about whether the third major approach, micro-insertion, has comparable effects for graduate students.} There may be several reasons for this, but one seems to be that micro-insertion has so far been used largely in undergraduate education and in professional programs, while the other two approaches have also been used widely in graduate education. Our project should therefore have the following products:

\begin{itemize}
  \item a) a systematic multi-campus approach for micro-insertion of ethics into two settings involving graduate students in engineering: classes and instructional laboratories;
  \item b) a means of widely disseminating micro-insertions via an online “Ethics In-Basket”;
  \item c) a procedure for systematically assessing the effectiveness of micro-insertion in classroom and laboratory;
  \item d) a series of pilot assessments using the procedure developed.
\end{itemize}

While this project is not comparing the effectiveness of micro-insertion to other approaches, we see our work as laying the foundation for such a comparison. There is certainly a practical need for comparison. While none of the three major approaches is incompatible with the others in theory, in practice they often compete for class time and student time—which, like most important resources, are both limited and in high demand.
There are at least two serious methodological problems that made us decide not to try a comparison of method as part of this project. First, given that all three methods work (as we now have good reason to believe), any differences in effectiveness between them might not be large enough to observe except in studies involving hundreds, or even thousands, of students (depending on how large the differences in effectiveness are). Just getting a sufficiently large pool of graduate students comparable in most respects would take considerable work. Generally, graduate classes in engineering are not large. Second is the problem of working out testing instruments that are informative across courses and institutions (apart from the tests of judgment such as the Defined Issues Test). Getting a good measure of micro-insertion’s effectiveness seemed a large enough undertaking for one three-year project. Having achieved that, we could work on refining our approach to make interesting comparisons with modules and whole courses devoted to engineering ethics.

2. BACKGROUND: THE MICRO-INSERTION METHOD

2.1. Description

Since 1990, CSEP has worked to integrate ethics into undergraduate courses in science and engineering, both at IIT and at more than a hundred other institutions of higher learning around the country. NSF funded this work under three substantial grants. CSEP has also worked with primary and secondary school teachers in the Chicago area to help them include ethical issues when they teach science (under NSF’s REIT grants).

CSEP’s unique emphasis has been micro-insertion. We have, for example, taught faculty how to revise ordinary technical problems in science and engineering to bring out the ethical issues underlying such problems. Consider the left column of Figure 1, which shows a problem from a standard text in ECE 485, Computer Organization and Design, a course often seen as relatively inhospitable to teaching ethics. As it stands, the problem calls for three relatively routine calculations. There seems to be no room for ethics. The problem asks only about what is possible (“can”) and probable (“which would you purchase?”). Yet, with a little rewriting, this ordinary problem can become an interesting ethics problem. The right column of Figure 1 shows how.
Consider two different implementations, I1 and I2, of the same instruction set. There are three classes of instructions (A,B,C) in the instruction set. I1 has a clock rate of 6 GHz, and I2 has a clock rate of 12 GHz. The average number of cycles for each instruction class on I1 and I2 is given in the following table:

<table>
<thead>
<tr>
<th>Class</th>
<th>CPI on I1</th>
<th>CPI on I2</th>
<th>C1 usage</th>
<th>C2 usage</th>
<th>C3 usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>2</td>
<td>1</td>
<td>40%</td>
<td>40%</td>
<td>50%</td>
</tr>
<tr>
<td>B</td>
<td>3</td>
<td>2</td>
<td>40%</td>
<td>20%</td>
<td>25%</td>
</tr>
<tr>
<td>C</td>
<td>5</td>
<td>2</td>
<td>20%</td>
<td>40%</td>
<td>25%</td>
</tr>
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</table>

The table also contains a summary of average proportion of instruction classes generated by three different compilers. C1 is a compiler produced by the makers of I1, C2 is produced by the makers of I2, and the other compiler is a third-party product. Assume that each compiler uses the same number of instructions for a given program but that the instruction mix is as described in the table. Using C1 on both I1 and I2, how much faster can the makers of I1 claim that I1 is compared to I2? Using C2 on both I1 and I2, how much faster can the makers of I2 claim that I2 is compared to I1? If you purchase I1, which compiler would you use? If you purchase I2, which compiler would you use? Which computer and compiler would you purchase if all other criteria are identical, including cost.


You work for a CPU manufacturer as an engineer and are asked by your manager to compose a comparison analysis report for products of your own and your main competitor’s. Your report will be employed by the advertising department for publication. The information gathered from the market for you to work on is as following:

<table>
<thead>
<tr>
<th>Class</th>
<th>CPI on I1</th>
<th>CPI on I2</th>
<th>C1 usage</th>
<th>C2 usage</th>
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<td>2</td>
<td>40%</td>
<td>20%</td>
<td>25%</td>
</tr>
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<td>C</td>
<td>5</td>
<td>2</td>
<td>20%</td>
<td>40%</td>
<td>25%</td>
</tr>
</tbody>
</table>

The products of your own company and your main competitor’s are denoted as I1 and I2 respectively. I1 has a clock rate of 6 GHz, and I2 has a clock rate of 3 GHz. There are three kinds of most popular compilers in the market, denoted as C1, C2 and C3 respectively. For the same set of instructions which could be classified into three classes A, B and C, a summary of average proportion of instruction classes generated by each compiler is tabulated above. Also, the table contains a summary of CPIs of each CPU for different classes of instructions. C1 is a compiler produced by your own company, C2 is produced by the maker of I2, who is your company’s main competitor in the market, and the other compiler is a third-party product. The advertising department has designed an ad campaign around the slogan, “Ours is up to twice as fast as theirs.” You have been asked to comment. Generate a brief report which includes your analysis, calculation, and recommendation.

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The analysis students must perform is identical in the two versions of the problem. The student should find that speed is determined not only by implementation (I1 or I2) but also by the compiler used. “Ours” (I1) is twice as fast as “theirs” only using “our” compiler (C1). With “their” compiler (C2) or the other popular brand (C3), the speed advantage disappears (C3) or is even reversed (C2). The proposed campaign rests on a slogan which, though literally true, is misleading. The engineer should therefore recommend against it—in the interests not only of the public but also of the long-term reputation of the company.

The chief difference between the original problem and the revised version is a change of context. A problem originally about the private purchase of a computer (something any of us might do) has been transformed into a problem of engineering: The student (“you”) now has to make a professional decision. Unlike many problems in an engineering text which seem divorced from practice (though they are not), this one was always explicitly practical, but it was not explicitly about practicing engineering (that is, it did not ask what the decision-maker should do as an engineer). There was no reason why it could not be—as the rewrite shows.

There is nothing subtle or philosophical in the transformation this problem underwent; yet its transformation embodies the central idea of micro-insertion. The ethics comes with the professional context. Once engineering faculty understand this example, they can see that integrating ethics into technical courses need not involve bringing in anything extraneous or even a significant sacrifice of anything they are trying to do now. Ethics need not be an add-on; it can instead work much like an alloy, adding strength to the course without displacing ordinary content.

How might this problem be used—without much change in the course? One way to use it (consistent with micro-insertion) is much as one would any other homework problem. In class, the faculty member just goes through the calculations for this problem as for any other, noting at the end that the responsibility of engineers goes beyond avoiding false statements: for example, “You need to consider that people who don’t understand the technicalities will rely on your recommendation. Sometimes you have to tell them more than they asked—to protect them as well as the public.” The class then goes on to the next problem. This “low-dose” approach to ethics instruction takes almost no extra class time.

To formulate a series of such micro-insertions, one strategy developed by CSEP is to have specialists in ethics work with subject-matter specialists, for example, engineering faculty, to prepare the problems. By
integrating the resulting problems into their courses, faculty can provide students with repeated “low doses” of ethics in each course and, with proper planning, throughout an integrated curriculum. While we have also contributed to the other two approaches—for example, by developing discrete modules that might require a day or week of a technical class—we have come to believe that most engineering and science classes (and labs) lack that much time, in that large a chunk, to do ethics. Micro-insertion fits the technical curriculum in a way the larger-scale approaches to ethics do not.

Micro-insertion has two other advantages. First, it treats ethics as a routine part of ordinary engineering, not as something that occurs rarely and comes labeled as “ethics.” Students get used to seeing every problem not only as a technical problem but also as a potential ethics problem. Second, there is reason to think that many of the complex, dramatic, large-scale ethical problems that have become classic modules (such as the Challenger case) began with smaller decisions that (if they had been handled differently) could have prevented the later, larger one. We believe micro-insertion helps students learn how to prevent those larger ethics problems by attending to the smaller, day-to-day ethical problems that often lay at their origin. In short, the micro-insertion or “small-dose” approach to ethics has three properties:

- It is integrated throughout a course (rather than being presented as a discrete module at only one point in the course).
- It is based on modifications of small-scale technical problems.
- It emphasizes ethical issues that professionals confront in the course of their daily activities and are therefore easier for students and novice professionals to imagine encountering.

2.2. Initial Findings about the Effectiveness of Micro-Insertions

In the experience of CSEP investigators, micro-insertion allows for an effective integration of ethics across the curriculum, reinforcing the sense in which ethics is interwoven in the everyday details of engineering. Besides the usual anecdotal evidence, including testimonials from faculty who have taken CSEP workshops, we have some quantified evidence that most students notice even a small amount of micro-insertion and respond positively. This evidence consists of about 3700 student responses to courses in which micro-insertion has been used by faculty who have taken the ethics-across-the-curriculum workshop developed by CSEP. The students have been taught by one of the 45 IIT faculty who have taken the workshop (from 1991–1993), one of the 100 or so faculty
from other US institutions who have taken it (from 1994–2003), or one of the half dozen faculty from non-US institutions who have taken the workshop. Since we have already reported these results in detail elsewhere, we say no more about them here.7

While we are pleased with the student evaluations and the anecdotal evidence we have from faculty that micro-insertion seems to work, we think the time has come for systematic assessment of whether the method does in fact teach students a measurable amount of professional ethics. Such an assessment, whether confirming or disconfirming the efficacy of micro-insertion, would be an important contribution to our understanding of how to teach engineering ethics in particular and professional and research ethics in general. In addition, because most of the evidence we have so far gathered has come from undergraduate students, what we are now doing will allow us to compare the undergraduate response to micro-insertion to the graduate.

3. THE PRESENT PROJECT

We understand “ethics” here—engineering ethics in particular but also professional ethics in general, science ethics, and research ethics—to consist of special standards of conduct, something beyond what law, market, morality, and public opinion would otherwise require. Ethics, in this sense, is what typically appears in a profession’s code of ethics. We understand ethics in this sense to differ both from ordinary morality and from the philosophic study of morality. Ethics, in this sense, is part of the special knowledge needed to practice a certain occupation, something that must be learned much as other special knowledge is. However morally good our students are, they are not therefore prepared to be ethical in this sense. They must be taught.

We understand teaching ethics (in this special-standards sense) to consist, at least in part, of the following:

1) increasing student sensitivity to issues involving their profession’s standards: can they identify the ethical issues in a situation?
2) improving student knowledge about how to resolve an ethical issue once it has been noticed: everything from being aware of the appropriate standard to consider—and how to interpret it—to knowing where to go to file a complaint or ask advice;
3) enhancing student judgment: the ability to develop an acceptable course of action and provide a reasonable justification; and
4) increasing student commitment to the standards of their profession: the probability that the student will act on them.\(^8\)

Our project focuses on the first three of these outcomes; the fourth seems to pose special problems of assessment. Indeed, only recently have researchers developed techniques for measuring the first and second outcomes in ways that allow comparison across instructors and institutions.\(^9\) Michael Loui is the first to apply this approach to engineering (using his own classes at the University of Illinois-Urbana-Champaign).\(^10\)

For graduate education in engineering, there are at least three serious barriers to the use of the micro-insertion method: (1) absence of graduate faculty in engineering who know how to integrate ethics into their graduate courses, without substantially changing how they allot their time; (2) absence of resources—for example, of appropriate problems with ethics already inserted, as in the revised problem in Figure 1 above; and (3) absence of evidence that the method actually teaches students enough ethics to be worth the effort of developing micro-insertions.

There is another barrier—one that we think we may ignore—the (possible) scarcity in some engineering departments of faculty with enough “real world” experience to develop micro-insertion problems. We believe most, if not all, engineering schools have enough faculty with such experience. Micro-insertion does not require that every course in a program address ethics, only that a good many do. Engineering schools and departments differ a good deal. Some, like Caltech, may have relatively few faculty members with experience in the large non-academic (non-research) organizations in which engineers typically work, while others, like IIT or the Naval Academy, have many. Some departments, like electrical engineering, may have few or even no faculty members with non-academic experience in large organizations; others, like civil engineering, may have many. But even at a school like Caltech and even in a theoretical field like electrical engineering, a significant number of faculty today may have experience in “start ups,” a domain of “the real world” in which issues of professional ethics appear about as often as in any other. We therefore think we can have an important effect on engineering education—and, to a lesser extent, on science education as well—even if our efforts prove useful only to faculty with enough “real world” experience to develop suitable assignments.

We plan to overcome the three serious barriers to micro-insertion identified above by:
• teaching faculty and graduate students in engineering how to develop micro-insertions;
• disseminating micro-insertions to graduate faculty through a Web interface and database now being developed as part of this project—allowing users to search for micro-insertion problems and to submit new ones; and
• assessing the effectiveness of micro-insertion of ethics in the graduate-level engineering curriculum and, something apparently entirely new, comparing the effectiveness of micro-insertion in the classroom with micro-insertion in a research laboratory.

The following provides a more detailed look at what we are doing.

3.1. Development

We are overcoming the first barrier by teaching a small number of engineering faculty how to develop and use micro-insertion problems to integrate ethics into their graduate courses. This is a natural extension of the approach CSEP has used since 1990 (primarily for undergraduate courses): We have already conducted workshops (funded by the current grant) at IIT on developing and using micro-insertion problems. The chief innovation in the workshops held during the first year of the grant (2006-2007) was that participants included graduate students. Each of the four members of the IIT faculty attending the workshop brought four graduate students who were to work with the faculty member to develop more micro-insertion problems for a specified course. A similar workshop was held at Howard December 7, 2007. The problem in Figure 1 above is a product of one of the IIT workshops.

After the workshop, each faculty member will in subsequent years train graduate students in a specified course—as part of the course itself—to insert ethics into its problems, initially using as resources both the examples developed for the workshop and the graduate students trained in it. One of our hypotheses is that the process of looking for ethics issues in problems in order to rewrite them will itself develop ethical sensitivity in the graduate students who do the rewriting. That is, we anticipate that faculty, by using handouts and examples based on the workshop materials, will be able to assign students in a particular graduate class—say, Perturbation Methods—to turn seemingly ethics-free problems into ethics problems (as in the problem in Figure 1 above). They will be able to do that even if they have not taken a course in ethics or an ethics-micro-insertion workshop.
We are carrying out this project at three institutions at once: IIT, Howard University, and UIC. We are using more than one institution in part to have a large enough pool of graduate students to obtain interesting results, but in part too to have a variety of teaching environments, and a greater variety of faculty and graduate students than any one institution is likely to have. The pool is, of course, too small to produce statistically interesting results—unless the results are dramatic. But it is large enough to test ideas. Can faculty and grad students do what we think they can? Can the tests they develop test for what we are interested in?

Alan Feinerman, a faculty member at the University of Illinois at Chicago (UIC), is micro-inserting engineering ethics in the Microfabrication Applications Laboratory, a nano-fabrication facility for instruction as well as research and development. Since he manages two labs each year (each with 10 graduate students), one lab can serve as a “control,” allowing us to investigate (a) whether a lab is an equivalent, better, or worse environment for teaching engineering ethics to grad students than a conventional classroom and (b) whether a lab in which engineering ethics is explicitly discussed is a more effective environment for teaching engineering ethics than one in which ethics is taught “tacitly” (if at all).

In sum, the educational component of our project has two “waves” of micro-insertion development. The first wave consists of the set of workshops with faculty and graduate students to develop micro-insertions. The second wave consists of faculty and graduate students who have previously attended these workshops helping other students develop micro-insertion problems as they take graduate engineering courses or work in laboratories.

We already had evidence that graduate students can develop interesting ethics problems appropriate for the modular approach. From 1996 through 2001, the Association for Practical and Professional Ethics (APPE) ran an NSF-supported workshop each summer at Indiana University for graduate students in science and engineering from around the country. In many ways, the workshop was a conventional five-day introduction to issues in research ethics. But, in one significant respect, it was quite different. Each graduate student had to write a “case study” and commentary. Generally, the students drew on their own experience as graduate students—resulting in cases quite unlike anything then in the literature. The workshop faculty also wrote commentaries on the cases. The cases and commentaries, published in six volumes, provide a new resource for teaching (modular) research ethics. They are available at “Research Ethics: Cases and Commentaries:” www.indiana.edu/~appe/
cases.html. However, only a few of these cases are about engineering. Our project differs from APPE’s both by its focus on engineering (rather than science) and by investigating graduate students’ ability to formulate micro-insertions (rather than case studies). We have already shown that graduate students can develop interesting micro-insertion problems during a one-day workshop. We are waiting to see whether they can continue to do so under the guidance of faculty whom we also trained and whether they and their faculty can together transfer that skill to graduate students who have not gone through our workshop.

3.2. Assessment

While carrying on this program of micro-insertion, we are supposed to conduct research into its effectiveness. We will continue to use, in a slightly modified form, the questionnaire described in 2.2 above to evaluate subjective student response at the end of the semester. The primary change is offering response options on the more discriminating Likert scale rather than the yes/no option we have used until now. (By counting all favorable responses as “yes,” we can convert the new data into binary data, allowing comparison with earlier responses.) The questionnaire provides a subjective assessment of effectiveness. The chief innovation we promised was to make an objective assessment of any change in ethical sensitivity, knowledge, or judgment during a particular course. We have already learned one important lesson concerning such assessment.

We originally planned to give two in-class tests at the beginning of the semester and again at the end. One was to be the new version of the Defined Issues Test (DIT-2). The other was to be a test of “mid-level concepts” we were to develop ourselves. Once we began recruiting faculty for the workshops, we quickly learned that no one would join the project if either the pre-test or post-test occupied more than fifteen minutes of class time.

The pre- and post-test use of the DIT-2 was to show how much, if at all, micro-insertion improved the students’ moral judgment, an important component (and rough approximation) of professional judgment. While it may seem unlikely that a few micro-insertions would have any effect measurable by the DIT-2, Loui seems to have shown that even a thirty-five-minute film (without subsequent classroom discussion) can have about the same effect as a standard one-hour discussion of a “dilemma.”12 That surprising result suggests the hypothesis that several micro-insertions over a semester in a single course might have a similar effect. So, it is with considerable regret that we gave up hope of confirm-
ing (or disconfirming) Loui’s results. But the faculty fifteen-minute limit for testing in class made in-class use of the DIT impossible. We then considered having students take the DIT-2 online (outside of class). We eventually dropped that idea when we learned from colleagues at Georgia Tech that online tests outside of class tended to have a low response rate (well below 50%) and also tended to be filled out less reliably.

The other means of assessment, the test of intermediate concepts, comes from Muriel Bebeau’s work at the dental school of the University of Minnesota over the two decades.13 An “intermediate concept” is a category for guiding conduct (or organizing deliberation) that falls between the most general moral categories (such as “morally good”) and specific applications (“I should do this”). Examples of intermediate concepts in engineering are safety, data integrity, candor, confidentiality, and conflict of interest.14

To test directly for learning of intermediate concepts, we need a collection of intermediate concepts that (a) covers all the courses with which we are working and (b) are shared by most or all of them. This was not as easy as we thought. Graduate courses tend to be focused on specific technical problems. These differ a good deal from discipline to discipline even within the four engineering disciplines represented by the IIT faculty (and students) we have recruited (civil, electrical, chemical, and biomedical). Howard’s recruits and Feinerman’s add to that mix. We used the IIT workshops to help us identify appropriate concepts. We also used lists drawn up for other purposes, especially, a list Jason Bornstein, Georgia Tech, developed while planning an online course in research ethics for engineers.15 And, of course, we have circulated our list among relevant faculty and graduate students after the workshop. Once we had our list, we were ready to develop a pre- and post-test to see whether students had learned them.

Testing effectiveness of ethics teaching is no harder than other testing of increased sensitivity, increased knowledge, or improved judgment. Testing for effectiveness of ethics micro-insertion differs from testing for effectiveness of engineering teaching generally only in that the testing involves the relevant ethical concepts rather than other engineering concepts. For example, to see whether students have become more sensitive to the ethical issues raised by data integrity, we give students situations in which data integrity is an issue (say, a problem involving a data set that is “too good to be true”). If more of them recognize the problem (the need at least to flag a suspicious data set) after the course’s micro-insertions concerning responsibility than before, they are (all else equal) that much
more sensitive to that issue. Our problem is not testing for such things in principle but developing a test that provides useful data across a wide range of engineering courses (in fifteen minutes). We were trying to build on the method that Bebeau developed for dentistry and that others have successfully applied to social work, journalism, and other fields outside science and engineering. Loui seems to have shown how Bebeau’s method of testing knowledge of intermediate concepts might be extended to engineering, though his study concerns only his own undergraduates. The problem we face is that Loui had control of the content of his own course and Bebeau is working within the carefully structured curriculum of one professional program (one she helped design). Each has its own well-defined body of ethical knowledge, skill, and judgment to transmit. Our collection of graduate courses, though all in engineering, lacks such a well-defined body of knowledge. We cannot tell faculty what to integrate here and there in their classes. We must let them decide based on the needs of the particular class and the opportunities the syllabus offers. We must nonetheless have a way to register the effect, or at least some of the effect, of the ethics integrated into the course.

The pre- and post-testing for intermediate concepts could give us a measure of micro-insertion’s contribution to ethical sensitivity (the ability to see issues) and ethical knowledge (the ability to label issues with appropriate terms). Constructing an assessment instrument for intermediate concepts across different courses, disciplines, and institution is complex. Indeed, as we have worked on the problem and consulted experts in testing, our goal became increasingly modest. Finally, we gave up on a direct test altogether. We had run up against a natural law governing tests for sensitivity and knowledge (but not judgment), something like the conservation of energy. It might be put like this: The more general the test, and therefore the more useful for comparing across classes, the less able it will be to register much about the ethics that students learned in a particular class; the more specific the test, and therefore the more useful for registering what students learned in a particular class, the less useful it will be for comparison across classes. The best way to approach this problem, a way not open to researchers like us, is to define the body of knowledge first, structure the curriculum to teach it, and only then develop a test to assess it. Not having that option, we are trying to muddle through.

As of today, “muddle through” means letting each faculty member develop his (or her) own pre- and post-test. What will be reported to us for each student (identified only by a number) will be a decimal, the result of dividing the pre-test score by the post-test score. We are hoping that
all the decimals (or, at least, the average for each class) will be less than 1. We are also hoping that the corresponding decimals in our control courses will be closer to 1. Should our hopes be realized, we will have found a way to get standardized test results across classes without standardizing the classes or the test. The ratio would function much as a grade does. Each instructor has his own standards and yet we can compare grades across classes—and, within broad limits, draw reasonably reliable conclusions about how students are doing. If this decimal approach can be made to work, it will be a significant addition to our resources for assessing what students learn about ethics.

### 3.3 Dissemination

To make the problems prepared by faculty and graduates available to others, we are developing another innovation, the online Ethics In-Basket: a website that will differ from APPE’s “cases” site in three ways:

- First, the Ethics In-Basket will be dedicated primarily to micro-insertions rather than to modules.
- Second, the Ethics In-Basket will be an evolving resource rather than a static archive. As new micro-insertions are developed, they will be added to the Ethics In-Basket, not only during the three years of the grant but afterward. The site will be designed to allow anyone with a micro-insertion to submit it for CSEP review and eventual posting. The Ethics In-Basket should be a permanent, continuously growing contribution to the infrastructure for teaching ethics in engineering and science.
- Third, in place of commentaries, the Ethics In-Basket database will have cross-referencing capabilities that allow interested faculty anywhere in the world to search quickly for problems by ethical issue (intermediate concept), for example, conflict of interest, course (e.g., Perturbation Methods), topic (e.g., use of statistics), level of complexity, or some combination of these and perhaps other sorters.

CSEP has a primitive version of the Ethics In-Basket at [http://nsf.printobject.com](http://nsf.printobject.com)

While the enlarged site will focus on micro-insertion problems, we intend to keep and, indeed, to continue adding modules, other materials, and links as well. We believe the more inclusive the site, the more useful it will be—provided users can find what they are looking for, and that the material they find is written clearly and ready for use with students.
Because the Ethics In-Basket will be a much larger and more sophisticated version of CSEP’s current site, we are especially concerned that it be easy to use and that the micro-insertions and other materials be well-written, allowing faculty who access them to use them in their classes immediately. We are therefore involving faculty and graduate students in IIT’s technical communication program in designing the site and in evaluating and testing the site’s usability, especially its navigation and search functions; in addressing knowledge management issues such as developing appropriate search terms; and in editing micro-insertions for clarity and ethical relevance.

Usability evaluation is being conducted in IIT’s Usability Testing and Evaluation Center (UTEC). We have included in our senior personnel team the director of UTEC, who brings expertise in site design and usability evaluation and in coordinating student projects in those areas.

5. CONCLUSION

This project should contribute to both research and educational efforts in ethics education in at least three ways: development, assessment, and dissemination.

First, the project engages faculty and graduate students in engineering in developing micro-insertion problems through workshops on several campuses. It also engages faculty and graduate students in teaching other graduate students in engineering how to develop additional micro-insertion problems. It should, therefore, be self-disseminating in a way our other ethics workshops were not. And, if it is, it will also serve as a demonstration of a new way to disseminate micro-insertion.

Second, to assess the effectiveness of the micro-insertion approach, the project is trying to develop a way to test for learning of engineering ethics across a wide variety of courses. We are breaking new ground by undertaking assessment of one major method for teaching ethics—micro-insertion—using a variety of graduate student populations. This assessment, in turn, should lay the foundation for future research comparing the effectiveness of different approaches to ethics education (e.g., the micro-insertion and modular approaches), using the same method (or something like it).

Third, the Ethics In-Basket is being developed as an online resource to help disseminate ethics material throughout the graduate curriculum in engineering world-wide. The Ethics In-Basket should improve the infrastructure of ethics education in graduate programs in engineering—and,
eventually, in other scientific fields as well. While we are building on work already done, what we are doing is more than a small improvement on what we have already done; it should make a quantum improvement in the teaching of ethics in graduate courses in engineering—and in science.

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**NOTES**


5. For those interested in the details, Xiaohua Tian, the author of the revised problem, provides the following calculations:

Using C1, the average CPI for I1 is $(.4 \times 2 + .4 \times 3 + .2 \times 5) = 3$, and the average CPI for I2 is $(.4 \times 1 + .2 \times 2 + .4 \times 2) = 1.6$. Thus, with C1, I1 is

\[
\frac{3}{3 \times 10^9} = 16
\]

\[
\frac{15}{3.4} \text{ times as fast as I2.}
\]

Using C2, the average CPI for I1 is $(.4 \times 2 + .2 \times 3 + .4 \times 5) = 3.4$, and the average CPI for I2 is $(.4 \times 1 + .4 \times 2 + .2 \times 2) = 1.6$. So with C2, I2 is faster

\[
\frac{3 \times 10^9}{1.6} = 17
\]

\[
\frac{6 \times 10^9}{16} = \frac{17}{3.4}
\]

than I1 by factor of $3.4$. 

Using C3, the average CPI for I1 is \((.5 \times 2 + .25 \times 3 + .25 \times 5) = 3\), and the average CPI for I2 is \((.5 \times 1 + .25 \times 2 + .25 \times 2) = 1.5\), So I1 is as fast as I2:
\[
\frac{3 \times 10^9}{6 \times 10^9} = 1
\]

The conclusion is:

<table>
<thead>
<tr>
<th>CPU</th>
<th>Compiler</th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
</tr>
</thead>
<tbody>
<tr>
<td>I1</td>
<td>Faster than</td>
<td>Slower than</td>
<td>The same as I2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>16 ( \frac{12}{15} )</td>
<td>( \frac{17}{12} ) ( \frac{16}{15} )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I2</td>
<td>Slower than</td>
<td>Faster than</td>
<td>The same as I1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( \frac{16}{15} )</td>
<td>17 ( \frac{11}{16} )</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


11 Feinerman (without grad students) was the fifth faculty participant in the IIT workshops (since UIC is just over four miles from IIT).

12 Loui, “Assessment.”

13 See, for example, Bebeau and Thoma, “Intermediate Concepts.”
14 Right now, this is our complete list:

- Accessibility (designing with disabilities in mind)
- Animal subjects research
- Authorship and credit (co-authorship, faculty and students)
- Publication (presentation: when, what, and how?)
- National security, engineering research, and secrecy
- Collaborative research
- Computational research (problems specific to use of computers)
- Conflicts of interest
- Cultural differences (between disciplines as well as between countries)
- Data management (access to data, data storage, and security)
- Confidentiality (personal information and technical data)
- Human subjects research in engineering fields
- Peer review
- Research misconduct (fabrication, falsification, and incomplete disclosure of data)
- Obtaining research, employment, or contracts (credentials, promises, state of work, etc.)
- Responsibilities of mentors and trainees
- Treating colleagues fairly (responding to discrimination)
- Responsibility for products (testing, field data, etc.)
- Whistle blowing (and less drastic responses to wrongdoing)

15 This is the engineering equivalent of the short-course and test the federal government now requires anyone doing human subjects research to take (and pass).

16 Institute of Medicine, *Integrity.*

17 Loui, “Assessment.”