EMBEDDING ETHICS INTO AN ENGINEERING CURRICULUM

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Abstract - Ethics has long been a required topic in an ABET approved engineering curriculum, but the list of 11 requirements – known by most engineering educators as the “a-k criteria” of ABET 2000 makes it clear that ethics must be far more than simply a topic to be covered somewhere in the curriculum. Teaching ethics is an essential part of teaching professionalism and must be a foundational strand that runs throughout the entire curriculum. In this paper the approach that is under development at the Padnos School of Engineering (PSE) at Grand Valley State University will be described. Students are introduced to the “Honor Concept” (which includes an Honor Code) as freshmen. The PSE program requires 1500 hours of co-op experience which is normally divided into three semesters of full-time work alternated with academic semesters during the last two years of the program. This offers the faculty an opportunity to teach ethics as a natural aspect of professionalism through the academic requirements for co-op. These elements and other parts of the approach under development will be described as well as observations about the success of this approach to date.

Index Terms – ABET 2000, Ethics, Honor Code, Professionalism.

INTRODUCTION - WHY ETHICS?

“The final index to a nation’s destiny is within its people, in their commitment to principles and ideals and their willingness to sacrifice for the common good.” [1]

President Dwight D. Eisenhower

What President Eisenhower said about our nation is also true about our profession. The code of ethics for each of the major professional engineering societies in our country begins with the recognition that engineers must work to support the common good. Our responsibility in this area is clearly stated. One answer to the question, “why ethics?” is that it is a professional requirement for each individual engineer. President Eisenhower’s statement also imp lies a group commitment to shared principles. In this sense it is also a requirement for responsible citizenship. As our society becomes more and more dependent on technology at the same time that it becomes less and less able to understand that technology, the need for engineers who take this responsibility for the “common good” is amplified. This is a responsibility that we assume individually as professionals, but it is also a responsibility that we assume as a professional group. Stefano Marzano linked engineering design to responsible citizenship in this way, “Design is a political act. Every time that we design a product we are making a statement about the direction the world will move in…we must be aware of our power.” [2]

ENGINEERING ETHICS – CURRICULUM CHALLENGE

Engineering educators are called upon to prepare young engineers to meet the challenge of socially responsible and ethically sound practice of our profession. How do we teach this? Most engineering educators would agree that ethics is important but as noted by S. Pfatteicher, “The current engineering ethics “dilemma,” in short, has been to find a way to provide meaningful ethics instruction to all engineering students without overburdening the faculty, without increasing graduation requirements, and without removing essential technical material from the curriculum.” [3]. One approach would be to require at least one course in which ethics is a primary topic. In 1999, Karl Stephan [4] published the results of a survey of 242 institutions listed in the 1996-97 ASEE Directory of Undergraduate Engineering Statistics. For the study, he looked for at least one required ethics - related course for engineers in the catalog for each institution. He found that fewer than 27% had such a requirement. For most students this requirement must be met in some other way, but how is it met?

Another approach is to weave an “ethics theme” throughout the curriculum. This is more difficult and it involves a commitment by a majority of the faculty to carefully build an intellectual foundation for ethical practice. “Watch your thoughts; they become words. Watch your words; they become actions. Watch your actions; they become habits. Watch your habits; they become character. Watch your character; it becomes your destiny.”[5] These words provide us with a challenge and with a plan. We are in the character-building business. We must begin with teaching how to think and to develop certain careful and truthful habits of the mind. Embedding ethics into an engineering curriculum is ultimately about instilling truth at the most fundamental levels of engineering practice. As a profession we have been entrusted with special and very powerful knowledge. That knowledge comes with a responsibility to use it wisely and for the common good. Making ethical practice of engineering second nature for our students will happen most effectively if it becomes a part of the fabric and culture of the engineering department. This paper is about how the faculty of the Padnos School of

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Engineering (PSE) is attempting to weave ethics into the fabric of their curriculum.

**IS ENGINEERING ETHICS DIFFERENT?**

In his book, *The Civilized Engineer*, Samuel Florman proposes that, for engineers, ethical practice involves more than morality or “goodness”. He states: “The greatest threats to moral engineering are carelessness, sloppiness, laziness, and lack of concentration.”[6]. For engineers, competence is an important part of ethical practice and this is something that would most likely not be effectively addressed from the viewpoint of other academic disciplines. Donald Goddard [7] has reported an interesting way to make this point using written design reports in which students complete “premier calculations”. While other calculations can be completed to what he calls “homework standards” of accuracy, premier calculations must be carefully documented, edited, and checked by another student. The student who signs off on the calculation suffers a greater penalty for errors than the student who prepared the calculation. In this way presents the issue of clarity and accuracy as ethical issues embedded in a design project.

Students who encounter ethics from within the discipline of engineering first and then take ethics from a different academic discipline, such as philosophy for example, will be able to compare and contrast different approaches and develop critical thinking skills. This point is more fully explored by Pfatteicher [8].

Richard Devon [9] presents another aspect of engineering ethics as he explores group (as compared to individual) decision-making. He comments: “It really is not very important how ethical engineers are, if they do not understand the implications of their designs.” This adds yet another twist to ethics for engineers. To answer the question posed, yes, engineering ethics is different, and the differences for our profession are best addressed from within the discipline.

**INFLUENCES TO THE P.S.E. APPROACH**

There are two major influences that have shaped our approach (in the Padnos School of Engineering, PSE) to making ethics instruction fundamental in our curriculum. The military academies – especially the United States Military Academy at West Point and the United States Naval Academy have greatly influenced our thinking. The second major influence is our experience with the development of curriculum materials to teach environmentally responsible design. Each of these influences will be described briefly in this section and then more fully as the PSE approach is described.

**Military Academies:** The author taught at the United States Naval Academy from 1982-1989 and has, in more recent years, developed a dialog with faculty at West Point. The author’s son, currently a cadet at West Point, has also provided many valuable insights. While there are great differences between civilian schools and military academies, Col. L. Donnithorne, in his book, *The West Point Way of Leadership*, notes that differences in military and civilian leadership “are differences in degree, not in kind.”[10]. Col. Donnithorne (now a civilian college president) details the West Point approach and discusses how this approach can be used in civilian schools to produce leaders of character.

The military academies teach professionalism most effectively by modeling it at all times both inside and outside the classroom, by requiring students to practice professionalism at all times, and by making a commitment to critique that practice at all times. A military influence is felt in all classes, perhaps most visibly by the requirement to wear uniforms and to live within a formal command structure, but it is also felt through the choice of examples presented in class and the instructors’ willingness to share life experience with the material being taught. While civilian schools cannot require uniforms or enforce a command structure, they can make a commitment to model what they teach at all possible times, to require students to practice engineering under many circumstances, and to be willing to critique student practice both formally and informally. In a real sense, an excellent engineering instructor is always looking for “a teachable moment” and seizes it when it occurs in or outside of class. There is much to learn from the military academy approach and the specific areas that have been adopted by PSE will be more fully discussed throughout this paper.

**Environmentally Responsible Design Curriculum:** In the early 1990’s the faculty of the Padnos School of Engineering (PSE) was under contract to produce a curriculum to teach environmentally responsible design. We struggled with the most effective method to fulfill this contract. One option was to develop a course or possibly a series of courses – maybe even a concentration area in environmental engineering. The problem with this approach was that a single course or even a series of courses were unlikely to change the thought patterns and intellectual habits of all of our students. Such an approach would also most likely involve elective courses that would be taken by just a few students. We wanted to change the culture of the engineering school and to have an impact on the preparation of all students. Adding required courses to the curriculum was certainly not an option. In addition to an already overcrowded curriculum, we were overwhelmed by the amount of new information that we would be required to master and teach. For example, environmental regulations are just a small part of the responsible design approach. We sent for just one piece of legislation – the Michigan Polluter’s Pay legislation. The book containing just this legislation was about 1 inch thick and the lawyers’ interpretation was a 2 inch thick volume. This was just one legislative act and it was overwhelming. Our students would not be able to read through these volumes of legislation, understand them, and
also be able to complete the coursework already required in engineering.

Indeed, we decided to develop curriculum materials that could be used in courses that are normally required for all engineering students. We also decided to develop materials for courses at all levels from the freshman year through the senior capstone design project. Finally, we decided that we would use environmental problems as a context for teaching the material that we already taught and that rather than teaching students about environmentally responsible design, we would set up exercises in which they would be required to practice environmentally responsible design. They learned about regulations when the exercise required them to comply with regulations. The instructor could then use this experience as an opportunity to outline how the EPA and state DNR or DEQ agencies have structured regulations. We also could teach them where the details could be found when needed.

We developed a series of exercises for courses like freshman design, thermodynamics, and senior project. We also developed a short ethics “reader” – a series of selected articles that explored the philosophical base for practicing environmentally responsible design and we developed discussion questions to explore the ideas as well as the writing technique used to present those ideas. The resulting volume, titled Teaching Environmentally Responsible Design [11] received awards from ASME and from MSPE for the innovative approach. The most important thing to note is that the approach was, and still is, very effective. (A very similar approach using environmental issues and involving ethics is reported by Nair [12].) We knew that we had to involve students in the practice of what we were trying to teach and that they had to encounter it in almost every major learning experience. This was carried forward into our approach to ethics.

THE PSE APPROACH – UNDER DEVELOPMENT

In the early 1990’s the PSE faculty adopted a Mission and Values Statement. In this we followed the example of many of the manufacturing plants in our area (many of them co-op employers associated with PSE) that adopted such statements as a part of the quality movement. We also emulated the military academies who clearly publish a mission statement. Such a statement serves to focus faculty efforts and it serves as a guide for new efforts. The last paragraph of the PSE Values Statement says: “Just as we value each individual in our community, we value the environment in which we live. The engineering community strongly influences the environment through the practice of its profession. For that reason we will strive to build into our curriculum an awareness of, and a sensitivity to, those areas in which engineering practice affects the environment. Such awareness extends beyond technical knowledge to include ethical responsibility in the practice of our profession.” For many years this statement served to guide faculty thinking and framed copies of the Mission and Values Statement were predominantly displayed, but it was hard to get the students to “buy into” these ideas. There was no requirement for the students to wrestle with the meaning of this statement.

HONOR CODE

Last year, in response to numerous “misunderstandings” on the part of students, the PSE faculty adopted an Honor Code very similar to the Honor Code at West Point. We have always had the university student code of conduct, but we found that most students had never bothered to read it. Certainly they had never wrestled with how to apply these ideas to their own professional lives. The same was true for the professional engineering society codes of ethics and our own mission and values statement.

On their first day at the academy, cadets at West Point are given a card to carry in their wallets with the Honor Code on one side and three “rules of thumb” to be used in the application of the honor code on the other side. We decided to produce a similar card, to laminate it to give a sense of permanence, and (like West Point) to make the introduction to this concept a memorable event. New cadets receive their first honor instruction from older cadets in a classroom setting. They are asked to read both sides of the card and to look up when they are finished. The older cadet then asks if there are questions, and then explains that this is the code of conduct that applies to all cadets. This is a professional requirement and expectation. Failure to live by it will result in dismissal from the academy. We hand the card out at freshman orientation and ask them to quietly read it and look up when they are finished. We also review a statement about the Honor Concept and its professional importance that is printed on a folded card into which the Honor Code card can be inserted. This statement is to be signed by the student and a copy is filed in the student’s record. Figure 1 shows the 2 sides of the honor code card and figure 2 shows the honor concept explanation.

We felt that it was important to place the honor code within the context of professional expectations, so we prefaced the statement of the code with an explanation of its importance. The rules of thumb were adapted to our concerns – especially the first rule. As is the case for cadets, the rules of thumb are printed on the back of the card. To illustrate how the rules of thumb can be used we present a short case study based on our own experience of students using the work of others in electronic form and handing it in as original work. This gives us an opportunity to discuss how copying can undermine the integrity of the grading process and seriously damage the learning environment. (Note: The Honor Code statement is almost identical to the West Point statement – we replaced “cadet” with “engineering student”; we did check with officers at West Point to be sure that this was allowed. The statement is considered to be part of the public domain.)
While knowledge and skill are certainly important to engineering practice, an engineer’s integrity is even more important. You must establish this integrity as a student. The professional engineering community monitors itself to establish trustworthiness or integrity. For that reason:

An engineering student will not lie, cheat, or steal, or tolerate those who do.

Rules of thumb:

1. Does this action attempt to deceive anyone or allow anyone to be deceived? Handing in or using someone else’s work in electronic or any other form is deceiving my instructor. Grades are assigned to assess my grasp of a concept or skill for future use. If I choose to evade the evaluation or grading process in this way I will deceive my instructor, but I will also deceive my future employer, the clients who will depend on my engineering expertise, and the general public.
2. Does this action result in an undue advantage to which I would otherwise not be entitled?
3. Would I be satisfied by the outcome if I were on the receiving end of this action?

The Spirit of the Honor Concept

The Honor Concept is way of life that affects every part of life - rather than a set of regulations for which violators will be punished. It should extend to all areas of an engineer’s life – personal as well as professional because the habits of the mind (such as integrity or honesty) that rule one area also tend to rule others – especially when under stress. The Honor Concept is pro-active rather than re-active; its main goal is not to punish but to build the level of trust-worthiness or integrity of every member of the engineering community. Students must be trained in the Honor Concept as an essential part of their preparation to practice engineering in an ethical manner.

Application: At all times I should consciously do the right thing because it is the right thing to do and not out of fear of punishment. If I, as an engineer, cannot be trusted, no amount of skill or knowledge will be useful to others. Because of the level of public trust placed in engineers, the Honor Concept is absolutely essential to the engineering profession. If I cannot be trusted, I also cannot be tolerated as a member of the professional community of engineers.

Signature/date: _________________________________

FIGURE 1
THE TWO SIDES OF THE HONOR CODE CARD

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FIGURE 2
EXPLANATION OF THE HONOR CONCEPT AND APPLICATION TO BE SIGNED BY EACH STUDENT

The Spirit of the Honor Concept is printed on the inside of a double-sized card that is folded around the Honor Code card. The outside of this card has the PSE logo on the front of it and a list of the professional societies with student sections at Grand Valley State University on the back of it. All of this places the honor concept within the context of professional practice.

Before we had the engineering honor code we had used a video with academic ethics case studies in our introductory classes. Two things kept this from being effective. The acting for the video was provided by engineering professors and students rather than professional actors. Students naturally viewed this as entertainment and the quality of the acting kept them from taking it seriously – even if they were asked to use the university student code to evaluate the cases. Also, there was no way for students to seriously identify the ideas presented from an engineering student perspective. When we had our own Honor Code, we were able to hand out the cards and discuss them before showing the video. Then we showed the videos and asked the students to use the rules of thumb to identify and discuss the ethical issues. This provided the students with an opportunity to practice using the Honor Code and it worked very well. Students took the material seriously and were able to overlook the quality of the acting when they were required to focus on the application of ideas. Signing a statement of agreement also helped to heighten the perception that they were entering a profession with high standards for conduct.

THE CO-OP PROGRAM

Padnos School of Engineering (PSE) has a mandatory co-op program. All students apply for secondary admission to the school after completing the engineering fundamentals. This typically occurs at the end of the sophomore year. At that point students interview for co-op positions and are placed with a company beginning with the summer preceding their junior year. They then alternate full-time work and school semesters on a year-around schedule to finish the program at the end of the summer in the senior year with a full year (3 semesters) of work experience. The entire program increases a sense of professionalism as our students begin their work experience as engineers. It also offers a golden opportunity to teach ethics in the context of professionalism.

During each co-op semester students have some academic assignments in addition to working. One part of these assignments is always an assigned book with a book report. For the first co-op students read The Unwritten Laws of Engineering [13], published by ASME Press. This short book (59 pages) effectively addresses the topic of professional conduct. Even the appendix of this little book is very helpful for our ethics instruction; it includes the code of ethics for ASME, IEEE, and ASCE. This works very well for us because we also assign a short ethics case study during the co-op semester. The case study centers on engineering student experiences and it includes questions designed to make the student reference the professional society codes as well as the PSE honor code. At the end of the semester we hold one evening meeting where the main...
activity is small group discussions of the case study with faculty members acting as discussion facilitators. Students who cannot attend the meeting must write a formal paper answering the case study questions. Students who do attend the meeting are asked to hand in their notes about the case study. This requires the students to put at least some effort into exploring an ethical issue using the codes of ethics that apply to them as students and also as professionals. The small group discussions allow them to test peer reactions against their own and faculty members have an opportunity to provide mentoring. There is no grade assigned for this discussion; this enables all participants to concentrate on the free exchange of ideas rather than the formalism of grades. The case studies are completed in each of the three co-op semesters and we are working on a collection of case studies based on actual student experiences.

Using student experiences rather than published professional case studies does seem to make this a more meaningful exercise for students since they are better able to relate to the cases. When the collection of case studies is complete it will parallel the “Hip Pocket Guide” formally used by second year cadets at West Point as they mentor the first year students (plebes) assigned to them. In civilian schools we cannot take advantage of a military command structure, but this is one way to encourage peer mentoring in our school. The fact that we can fold this into the co-op experience which is already a wonderful tool to enhance professionalism, works very well for us. For schools without a formal co-op program this could possibly be incorporated into a required class or student professional society activities.

Finally, in the third (last) co-op semester the assigned book comes from a list of books having a central technical ethics issue. Students are free to choose which book to read, but they are asked to write a report in which they identify the ethical issue, show how the author presents the issue, and comment on the solution that the author presents. Of course they also complete the ethics case study assigned and they are encouraged to discuss the book and the case study with the engineers at work.

Volunteer Community Service Projects

The elements of our program discussed so far are all required in the curriculum. In addition, we have fostered the development of a number of community service projects involving engineering and administered through the student sections of the professional engineering societies. In her article titled Teaching vs. Preaching:EC 2000 and the Engineering Ethics Dilemma, S. Pfatteicher urges educators to clearly distinguish between hopes and expectations when considering student outcomes for teaching in all areas, but in ethics in particular.[14] It is our expectation that students will understand ethics and social responsibility, and that they will be able to think clearly and critically. It is our hope that they will move beyond understanding to some level of action and possibly even advocacy. To encourage students to take this step we have invited them to join us in a number of community service projects ranging from sponsoring the 5th grade class of a local inner-city school - to repairing bicycles and giving them to children whose parents cannot afford them – to the design, building and furnishing of the playroom in a local homeless shelter for women and children – to projects that directly benefit the student body at PSE.

In each case we present the project as an opportunity to exercise responsible citizenship and we attempt to link it to our professional responsibility to “enhance human welfare” - as required by the professional codes of ethics. For example, sponsoring the 5th grade of a local inner-city school is in its third year. When we present the opportunity to join the faculty in this project we note that inequities in academic achievement in inner city schools is a problem that affects all citizens. This is something that we can do, and as a reason for action we quote President Hoover: “It (liberty) demands freedom from frozen barriers of class, and equal opportunity for every boy and girl to win that place in the community to which their abilities and character entitle them.” [15] This is an idea that we want our students to consider for themselves, but they see it more clearly as they help to provide an opportunity to be competitive to children who might not have this chance under normal conditions.

Not all students volunteer and not all faculty members volunteer, but there is enough involvement to affect the culture in the school. A large number of projects are available with opportunities for students to contribute as little as 20 minutes of time and still have a meaningful experience. When a project is in progress it does become a topic of conversation and it provides an opportunity for students and faculty to engage in thinking about our professional responsibilities to our community. All of our students can benefit from such conversations. Providing an opportunity for reflection and taking the time to say thank you at the end of a service project is an important aspect of these projects that is often overlooked. If you decide to do service projects note that a simple pizza party at the end can provide a wonderful informal setting to talk with the students about why service is important and how it is related to our shared code of conduct.

Links to ABET 2000

The overall approach used by PSE to teach ethics has been to embed our ethics teaching into the entire curriculum. By creating a culture in which ethics is a foundational strand we also increase the probability that the strand is picked up in many of the other courses taught in our department. Faculty members who think about ethics can certainly bring up ethical issues as something to consider in any engineering problem – and students who are sensitive to ethical issues may very well introduce them without the instructor’s prompt. When our students do take the required ethics class from a philosophy professor they are in a better position to
learn more because they have thought about many of the issues within the context of engineering. It is difficult to quantify this but it is definitely an intangible benefit of our approach. The spirit of the ABET EC 2000 Criteria (shown below) is to build certain strands into an overall curriculum.

TABLE 1: EC 2000

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<thead>
<tr>
<th>Criterion 3: Program Outcomes and Assessment</th>
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<tr>
<td>Engineering programs must demonstrate that their graduates have:</td>
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<tr>
<td>a.) ability to apply knowledge of math, science, and engineering</td>
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<tr>
<td>b.) ability to design and conduct experiments and analyze and interpret data</td>
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<tr>
<td>c.) ability to design a system, component, or process to meet desired needs</td>
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<tr>
<td>d.) ability to function on multi-disciplinary teams</td>
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<tr>
<td>e.) ability to formulate, identify, and solve engineering problems</td>
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<tr>
<td>f.) understanding of professional and ethical responsibility</td>
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<td>g.) ability to communicate effectively</td>
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<td>h.) broad education necessary to understand the impact of engineering solutions in a global and societal context</td>
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<td>i.) recognition of the need for, and ability to engage in life-long learning</td>
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<tr>
<td>j.) knowledge of contemporary issues</td>
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<tr>
<td>k.) ability to use the techniques, skills, and modern engineering tools necessary for engineering practice</td>
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Criteria f (understanding of professional and ethical responsibility) and h (broad education necessary to understand the impact of engineering solutions in a global and societal context) are directly addressed by the approach to teaching ethics presented in this paper. The interplay between topics formally covered in class and topics presented in a professional work context (co-op) allows us to create an environment in which ethics becomes an essential element of our program. In essence we have shifted our focus from delivering a prescribed content to providing a context to practice the profession of engineering. This does not mean that we are free to ignore content, instead we bring the content to the students in the more meaningful context of engineering practice. Sometimes this may mean that we will lose some content, but then we will emphasize criterion i by telling the student where they must look to find the content not directly required for the project at hand. All of the criteria that are difficult to address in a more traditional approach to engineering education: d,f,g,h,i,and j can be effectively addressed by this approach.

SUMMARY

This paper presents the approach to teaching ethics that is currently in progress in the Padnos School of Engineering. Are we finished with our work? Certainly not! We are, however, learning and we are open to learning more and changing our approach if a better idea is presented. What we have attempted to do is to create a culture in which the responsible and ethical practice of our profession is taught from the very beginning of our program. The students who are taught in this way will develop the habits of the mind that will enable them to practice engineering in an ethical manner.

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REFERENCES