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Service-Learning and Engineering Ethics*

Michael S. Pritchard, *Western Michigan University, USA*

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ABSTRACT: *This paper explores ways in which service-learning programs can enhance ethics education in engineering. Service-learning programs combine volunteer work and academic study. The National Society for Professional Engineers (NSPE) and American Society for Civil Engineers (ASCE) codes of ethics explicitly encourage engineers to seek opportunities, beyond their work-related responsibilities, to serve their communities. Examples of how this can be encouraged as a part of the educational experiences of engineering students are explored.*

> *Calvin*: How good do you have to be to qualify as good? I haven't **killed** anybody. See, that's good, right? I haven't committed any felonies. I didn't start any wars. I don't practice cannibalism. Wouldn't you say I should get lots of presents?
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> *Hobbes*: But maybe good is more than the absence of bad.
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> *Calvin and Hobbes*[1]

Current Accreditation Board for Engineering and Technology (ABET) requirements for accredited engineering programs in the United States include helping students acquire "an understanding of the ethical characteristics of the engineering profession and practice."[2] ABET 2000 more specifically requires engineering programs to demonstrate that their graduates also understand the impact of engineering in a global and social context, along with a knowledge of current ethical issues related to

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Address for correspondence: Michael S. Pritchard, Willard A. Brown Professor of Philosophy, Director, Center for the Study of Ethics in Society, Associate Dean, the Graduate College, Western Michigan University, Kalamazoo, MI 49008, USA, email: pritchard@wmich.edu

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engineering. It also requires students to have a "major design experience" that includes ethical factors in addition to economic, environmental, social, and political factors.[3]

The recent mushrooming of engineering ethics resources (books, articles, cases, videos, and the like) can be of great assistance in meeting these requirements. However, in this paper I will explore a possibility that has received relatively little attention in engineering ethics literature—*service-learning*.[a] This involves combining community service and academic study in ways that invite reflection on what one learns in the process. Given ABET 2000's "major design experience" requirement, the idea of service-learning in engineering may be especially promising. But this idea is important for another reason. Much of the engineering ethics literature dwells on the negative, i.e., wrongdoing, its prevention, and appropriate sanctioning of misconduct. These will always be fundamental concerns. But there is more to engineering ethics than this. There is the more positive side that focuses on doing one's work responsibly and well, whether in the workplace or in community service.

Is community service an aspect of engineering ethics?

Given the common association of engineering ethics with wrongdoing and its prevention, it might be asked whether community service should be regarded as a part of engineering ethics at all. However, it is not at all uncommon for other professions to include *pro bono* service as an important feature of their professional ethics. This is based in large part on the recognition that professions provide services that may be needed by anyone, but which not everyone can afford or easily access. Medical and legal services readily come to mind. But this is no less true of engineering.

Is this acknowledged in engineering codes of ethics? It is in at least two: The National Society of Professional Engineers (NSPE) and the American Society of Civil Engineers (ASCE).[b] I will discuss each code's provisions briefly. Emphasizing the crucial impact that engineering has on the public, the Preamble of NSPE's *Code of Ethics for Engineers*[6] states that engineering "requires adherence to the highest principles of ethical conduct on behalf of the public, clients, employers and the profession." Following this, the code lists as its first Fundamental Canon that engineers are to hold paramount the safety, health, and welfare of the public in the performance of their professional duties. This provision is repeated as the first entry under *Rules of Practice*.

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a. Two notable exceptions are Edmund Tsang, Why Service Learning? And How to Integrate it Into a Course in Engineering,[4] and Rand Decker, Professional Activism: Building from Service-Learning, Reconnecting Community, Campus and Alumni through Acts of Service,[5] both in Ritter-Smith and Saltmarsh's *When Community Enters the Equation: Enhancing Science, Mathematics and Engineering Education Through Service-Learning*.

b. Why other codes are silent on this matter is not something I will explore in this paper. However, this might be an interesting topic for discussion.

Unfortunately, the *Rules of Practice* section says very little about what specifically this provision requires from engineers. The only further specifications concern: 1) reporting to proper authorities when one's judgment is overruled and public safety, health, or welfare is endangered; 2) reporting alleged violations of the Code; and 3) approving only those engineering documents that show proper regard for public safety, health, and welfare. That is, there is a rather striking shift from the positive to the negative.

This shift is in line with the already noted major emphasis in engineering ethics literature, wrongdoing and its prevention. However, later the Code returns to the positive. Under Section III, *Professional Obligations*, the second entry says: "Engineers shall at all times strive to serve the public interest." Subsection a. under this obligation reads: "Engineers shall seek opportunities to be of constructive service in civic affairs and work for the advancement of the safety, health and well-being of their community." Noteworthy here is the assertion that engineers are to *seek opportunities* to be of service to the community. Furthermore, there is no qualifier, "in the performance of their professional duties." This suggests that engineers's obligations in regard to public well-being are not restricted to their responsibilities within their place of employment.

Again, there is no specification of what taking this obligation seriously might entail. Perhaps the best way to illustrate what this might involve is through examples. However, the engineering ethics literature thus far has not devoted much attention to this aspect of engineering responsibility.[c]

The ASCE *Code of Ethics*[8] differs from that of NSPE mainly in regard to its explicit emphasis on enhancing the environment and complying with principles of sustainable development.[d] Its first *Fundamental Canon* reads: "Engineers shall hold paramount the safety, health and welfare of the public *and shall strive to comply with the principles of sustainable development* in the performance of their professional duties." (Emphasis added.) Subsection e., directly under this reads: "Engineers should seek opportunities to be of constructive service in civic affairs and work for the advancement of the safety, health and well-being of their communities, and the protection of the environment through the practice of sustainable development." Subsection f. reads: "Engineers should be committed to improving the environment by adherence to the principles of sustainable development so as to enhance the quality of life of the general public."

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c. I have made an initial effort in my "Professional Responsibility: Focusing on the Exemplary."[7]

d. In November 1996 the ASCE Board of Direction adopted as its definition of 'sustainable development': "Sustainable Development is the challenge of meeting human needs for natural resources, industrial products, energy, food, transportation, shelter, and effective waste management while conserving and protecting environmental quality and the natural resource base essential for future development."

Although the NSPE and ASCE provisions are rather broadly stated, they do provide a rationale for concluding that, at least from the perspective of two major professional engineering societies, community service is an important feature of engineering ethics.

Service-learning

Service-learning provides an opportunity for students to understand and appreciate this. At the same time that many have complained that our students are part of a "me-generation", there has been a marked increase in student interest in volunteer work. Until fairly recently, however, there has not been a strong correlation between students's academic pursuits and the sorts of volunteer work they undertake. Noting this lack of correlation, organizations such as Campus Compact have made concerted efforts to encourage the development of academic programs that explicitly encourage students to seek volunteer work related to their course of academic study and to reflect quite self-consciously on the connections.[e]

Academic areas such as teacher education and the health care professions immediately suggest themselves as candidates for service-learning programs. Students preparing to become teachers can offer tutorial or mentoring services to the schools, students in nursing programs can volunteer their services to nursing homes or other health care facilities, and so on. But what about engineering students? Of course, they can volunteer tutorial services to the schools, particularly in areas of computer science, math, science, and technology that are relevant to engineering. But I want to broaden the net considerably by providing examples that are closer to actual engineering practice.

Service-learning in Engineering: A range of possibilities

Service-learning possibilities in engineering include: 1) a specific design project within a senior design course, 2) an Introduction to Mechanical Engineering course with a service-learning component, and 3) a student initiated organization for students across the engineering curriculum. These are only illustrations. There could be many variations, some of which may already be well in place. If so, I encourage their discussion.

The first example is a project undertaken by a group of electrical engineering students at Texas A&M in Tom Talley's senior design course.[f] This course is intended to help prepare students for the challenges in project design and management that they

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e. Campus Compact supports the development of service-learning programs throughout the country.[9] The objectives of Campus Compact can be addressed in science, mathematics and engineering education.[4-5]

f. This account is based on an article by Dave Wylie, "AVIT Team Helps Disabled Children."[10] I also interviewed the instructor, Tom Talley.

will confront in industry. In this case, the students were also introduced to community service.

Team members were undecided about what project to undertake until Tom Talley shared with them a letter he had received from the Brazos Valley Rehabilitation Center. The letter identified a need for an Auditory Visual Tracker (AVIT) to help in evaluating and training visual skills in very young children with disabilities. Most students, Talley said, end up only building a working prototype. However, in this case, he pointed out, "The students took on the project knowing that it was larger and potentially more expensive for them to produce than might be expected of a typical project."

"We like that it was a project that was going to be genuinely used," said team member Robert D. Siller. "It wasn't going to just end up in a closet. It's actually helping someone." Myron Moodie added, "When we presented the AVIT to the Center, we got to see some of the kids use it. It was worth it watching the way the children like it." However, completion of the project was anything but easy. One complication was that the team was interdisciplinary. It included a student from management, which meant that the team was introduced to the project management environment, giving the endeavor a more industry-like flavor than is typical of projects in Talley's design class. To further complicate matters, the management student was seriously injured in a car accident during the semester, although she was able to continue in the project. By the end of the semester the project was not quite completed. However, the students were so committed to complete a usable AVIT for the rehabilitation center that they stayed on after the semester.

What seems obvious from student comments is that they found the service aspect of their experience very rewarding. Whether this will encourage them to continue to seek out community service opportunities once they are fully employed engineers can be, of course, only a matter for speculation. Another matter for speculation is that this experience speaks positively about the kinds of engineers these students will become in their places of employment. Tom Talley, at least, is quite optimistic. He said, "They clearly went above and beyond—that's Aggie spirit. Someone is going to get some fine young engineers." I take his comment to include both what can be expected from these students as engineers in the workplace and as civic-minded contributors to the public good.

I share this optimism. I also believe that this particular kind of project—one taken to completion and one involving direct interaction with those being helped—can enhance students' understanding and appreciation of responsibilities they have both on the job and in community service. In this case, the project went well beyond designing a prototype; everything worked out well. However, this required very careful attention to the specific needs of the Center's staff and the children who were in need of assistance. This is a very important lesson in responsible engineering, whether volunteer or work related.

However, from a service-learning perspective, there are two important limitations to this example. First, although the students apparently did reflect on the significance of the service aspects of their experience, this was not a specific objective of the

project itself. Service-learning is distinguished by it's deliberate combining of service and study: "One of the characteristics of service-learning that distinguishes it from volunteerism is its balance between the act of community service by participants and reflection on that act, in order both to provide better service and to enhance the participants' own learning."[11] This project was not simply an instance of volunteerism; it was a class project. However, it was a project primarily in engineering design and, from the perspective of the class itself, only incidentally did it involve community service. Nevertheless, this is just the sort of project that could be undertaken with the full service-learning objectives in mind, and it looks like many of those objectives were, in fact, fulfilled even though this was not part of the official class agenda.

Second, a point related to the first, the AVIT project stands virtually alone. There may be other projects that lend themselves to service-learning objectives that are undertaken by students in Tom Talley's design class, or in other design classes at Texas A&M; but service-learning in engineering as a planned, co-ordinated activity would require a much more sustained effort. My second example is an illustration of this sort.

Edmund Tsang's Introduction to Mechanical Engineering course at the University of South Alabama includes a service-learning project.[g] Engineering student teams work with the Mobile school system and its Southeastern Consortium for Minorities in Engineering program. Students in this class have designed equipment for teachers and middle school students that illustrate basic principles of motion, energy, and force, and mathematical modeling. Although the first year engineering students in this class are just beginning their technical training, there are many different kinds of design projects they can undertake. Design projects undertaken for middle school students include:

- Pencil rocket launchers, along with a sextant to measure the height of the rocket's flight.
- A flush toilet used to illustrate lever and gravity speed, mathematical concepts of volume, and algebraic functions.
- Tools and activities for investigating the math and engineering behind bowling.
- A windmill and an anemometer for students to collect data about wind speed and energy.
- A solar cooker, a model greenhouse, and support for a solar panel to equip an outdoor classroom.

Tsang points out that his course is similar to model "introduction to engineering" courses described in 1994 Annual Conference proceedings of the American Society of Engineering Educators. However, the distinctive feature of his course is that the context for learning and practicing engineering design is that of service learning.

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g. Edmund Tsang's "Why Service Learning? And How to Integrate it Into a Course in Engineering",[4] provides a more detailed description of this course, as well as descriptions of service learning oriented courses taught by C. Dianne Martin (George Washington University) and Rand Decker (University of Utah).

My third example, perhaps the most ambitious of all, is the student initiated Case Engineering Support Group (CESG), at Case Western Reserve University (CWRU).[h] This is a non-profit engineering service organization made up of engineering students at CWRU who "design and build custom equipment to assist the disabled in therapy or normal daily activities."[13] The equipment is given to individuals at therapy centers at no cost. Founded in 1990 by CWRU undergraduate and graduate mechanical engineering students, CESG has become part of the Mechanical and Aerospace Engineering Department and has a full-time director. CESG has received donations of equipment from industry, financial support from the U.S. National Science Foundation (NSF) and the Case Alumni Association, legal services from CWRU's Law School Clinic, and cooperation and support from the medical and health care community in Cleveland.

In CESG's first year 18 students completed six projects. During the 1995-6 academic year 120 students completed 60 projects, as well as follow-up work on previous projects. CESG supports four major programs:[14]

- Custom Product Development Program: working with faculty members designing, manufacturing, and providing, at no cost to individuals, adaptive devices and equipment to help them gain a higher level of independent living skills; working with physicians, physical, occupational, and speech therapists in adapting, modifying, and providing devices and equipment.
- Technology Lender Program: repairing and adapting donated computer equipment and designing specialized software for those with special communication, vocational, or educational needs.
- Toy Modification Program: providing specially adapted toys to families of children with disabilities and to hospitals, and presenting related workshops to junior and senior high school students to stimulate interest in engineering as a career.
- Smart Wheelchair Project: working with the Cleveland Clinic Foundation's Seating/Wheeled Mobility Clinic, Invacare Corporation, and engineers at the U.S. National Aeronautics and Space Administration's Lewis Research Center to design, modify, and improve the "smart wheelchair," which is fit with special sensors and artificial intelligence routines.

The results of CESG's work thus far is very impressive and has received extensive media coverage.[i] CESG also offers to provide advice to others who might wish to set up programs similar to CESG's.

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h. At least it was until October 1997, the last time its website was modified. Detailed information about the aims and activities of CESG are provided at its website.[12]

i. The CESG website[12] provides examples. Media stories describe many of the very creative and helpful products designed for children with very specific needs.

An explicit goal of CESG is to "provide more and better services for people with disabilities in the community who cannot afford or locate devices that the CESG can provide for them."[15] So, this student-initiated and student-run organization certainly takes seriously the NSPE proviso that engineers have a professional obligation to seek opportunities to serve the community. CESG actually *creates* such opportunities for students. CESG also connects this service goal with engineering practice in general. Another of its basic goals and objectives is to "better prepare CSEG's engineering students for the practice of engineering."[15]

CESG's more general concern to better prepare students for engineering practice is noteworthy in two respects. First, there is the suggestion, of course, that cultivating an attitude of service (both in the workplace and in the community) is desirable. Second, there is the suggestion that providing engineering services involves competence, skill in working with and for others, and so on. That is, the basic responsibilities that apply to engineering practice in general also apply to those special activities that fall under the heading of community service. CESG projects *are* engineering work experiences—and, as in the AVIT example, by often working directly with those who need their services, students are made explicitly aware of the benefits and risks that can come from their work.

From a service-learning perspective, what else might be added to the CESG program? As in the AVIT project, the self-reflection students engage in may be more happenstance than deliberately structured. CESG students do meet regularly to discuss their projects. Since these projects are undertaken in a community service context, it is highly likely that some conversations pivot around the significance of service experiences themselves, but this does not seem to be a specific learning objective of CESG.

Teaching challenges

Service-learning projects must do more than provide service to others. They must also contain a learning component for those who provide the service, one that focuses on the notion of service itself. That is, service-learning projects require some sort of self-conscious reflection on the nature and significance of providing service to others. This can have a legitimate place in fulfilling ABET requirements that engineering students acquire "an understanding of the ethical characteristics of the engineering profession and practice." How, specifically, might this be incorporated in the engineering curriculum?

Edmund Tsang's inclusion of a service-learning component in his Introduction to Mechanical Engineering course has already been mentioned.[4,j] So, even introductory level courses could include service-learning components that encourage students to reflect on the nature and significance of providing service to others. However, perhaps the most obvious place for service-learning opportunities is in design courses. ABET

j. Specific teaching advice is contained in all the articles in *When Community Enters the Equation*.[16]

sets the stage for this in requiring students to have a "major design experience" that includes ethical factors in addition to economic, environmental, social, and political factors.

Service-learning opportunities introduce the ethical factor of service itself, which, as noted, is an aspirational goal in most engineering codes of ethics. For those engineers who aspire to do good, Hobbes's advice to Calvin is well taken: "But maybe good is more than the absence of bad." However, students may need guidance in determining what counts as doing good when engaged in a service-learning project. Acting on good intentions is not enough. As engineer and disaster relief specialist Frederick Cuny repeatedly insists, engineering assistance must carefully take into account the *context* in which help is offered.[7, 17-19] This may require sensitivity to not only individual differences among those with similar backgrounds but also vast differences in cultural, environmental, social, and political circumstances. Exposing students to some of Cuny's reflections would be quite useful.[k]

Although a fundamental ethical dimension of service-learning is the notion of service itself, there are other dimensions that are likely to be encountered in virtually any workplace environment. I will close with some ideas about these additional dimensions that I have gleaned from a service-learning program I have been involved in outside of engineering. For several years I have taught Introduction to Ethics in an Honors College cluster that also includes an introductory level communication course and a service-learning course. Twenty-five students enroll in this cluster. A requirement is that students write a term paper in which they discuss their service project and relate that experience to related ethics and communication concerns. None of these students have been in engineering. So, I have no samples of how engineering students might handle such an assignment.

However, I suspect that engineering students, like the students in our Honors College cluster, may experience a number of ethical challenges that they did not anticipate prior to undertaking their service project. Our students discuss problems they have working in teams, trying to figure out just what the needs they are trying to serve are and how this might best be done, trying to satisfy a supervisor or others with whom they are working, trying to decide what to do when they see something of which they disapprove, trying to decide what to do when they have made a mistake that has not been noticed by others, and so on. So, in addition to reflecting on the significance of community service itself, they find themselves addressing ethical problems very much like those they will have to deal with in their eventual place of employment as well. What this means is that, assuming that service-learning projects encourage a full discussion of the ethical dimensions of the students' experiences, a much broader spectrum of ethical questions will be considered than community service.

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k. Two other sources that might be helpful are: Sarah Kuhn's "Engineering Students Encounter Social Aspects of Production,"[20] and Eugene Schlossberger's "The Responsibility of Engineers, Appropriate Technology, and Lesser Developed Nations."[21]

Finally, service-learning experiences for engineers, precisely because they are closely related to students' preparation for their careers, can stimulate reflection on directions they want their careers to take and on the values and ethical ideals they hope to sustain in whatever pursuits they do eventually undertake.

All of this should seem especially appealing to those engineering educators who want their students to become responsible engineers both in the workplace and in their lives in the community.

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