Integrating Catamount Community Service-Learning Projects within Civil and Environmental Engineering Programs at the University of Vermont

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Innovations in Engineering Education

As part of a three-year National Science Foundation education grant recently awarded (9/2005), we have begun curricular reform in both our civil and environmental undergraduate engineering programs. The overall goal of this reform is to develop an educational framework that shifts from addressing problems in isolation to one that adopts a systems approach to engineering problem solving. We want our graduates to learn to incorporate both short and long-term environmental, social, political, regulatory and economic issues, not only into the problem solution, but into the problem definition as well. One of our key strategies for creating this educational experience is through the use of Catamount Community service-learning projects that we coined “adopt-a-town”.

The idea of the Catamount Community is to team each incoming class with a Vermont town or towns interested in working with civil and environmental engineering students on real engineering projects. Throughout their tenure and in numerous other engineering courses (starting in their first year), students work on projects with the Catamount Communities. The intent is not only to provide meaningful assistance to the community, but to introduce an engaging across-the-curriculum service-learning component that creates the opportunity for really integrating social, regulatory, political, economical, and environmental components into the curricula. One of the first steps has been training faculty members in the service-learning approach. This has been accomplished through the University of Vermont (UVM) service-learning faculty fellows program, attending service-learning presentations, reading books and articles, and discussions of service learning with each other. The second step was to research and contact potential Catamount Communities. This was incorporated as group projects into the first-year civil and environmental engineering course this past fall. Since then, several of the towns have expressed interest in participating in our Catamount Community program, and will be working with us in upcoming courses. Preliminary evaluation of faculty and students conducted by an education researcher is currently underway as part of our assessment.

1 Catamount is the name given to the mountain lions that once roamed Vermont. It is the University’s mascot.
INTRODUCTION/BACKGROUND

At this critical juncture in our technological evolution, with the rapid depletion of the world’s resources and an exploding world population, it is vital that we teach our current and future engineers a systems approach to engineering problem solving including concepts of sustainability. It is essential for the welfare and long-term viability of our planet that short and long-term social, environmental and economic impacts be considered and integrated into engineering solutions. Many voices within the higher education community have recently pointed out the dangers associated with knowledge fragmentation and disjointed curricula that characterize higher education at the moment, and have instead called for reform to reconstruct the unity and value of knowledge (e.g. Gregorian, 2004).

Recognizing the value of a systems approach to engineering education, the faculty of the Civil and Environmental Engineering programs at the University of Vermont has recently secured a departmental curriculum reform implementation grant from the National Science Foundation (NSF). Our primary goal is to implement an educational framework that shifts from addressing problems in isolation to one that adopts a systems approach, cutting across traditional disciplinary lines and fostering an integrated approach not only to problem solving, but problem definition as well.

The framework for our reform is a systems approach for engineering education that can be described best with reference to Figure 1, which represents a catamount paw. Catamount is the name given to the mountain lions that once roamed Vermont and is the university mascot. This approach includes incorporating environmental, social, political, regulatory and economic issues as well as systems thinking at all levels of the program. Systems thinking or a systems approach (Senge, 1994) is a framework for seeing and working with wholes, for focusing on interrelationships and repeated events rather than things. It consists of a set of general principles, specific tools, and techniques that have been developed with the aim of discovering the “constructs” underlying and interwoven within complex problems (Frank 2002, Khisty and Mohammadi 2001, Anderson and Johnson 1997, O’Connor and McDermott, 1997, Churchman 1968). We believe that systems thinking is critically important for developing sustainable solutions to world problems.

At the core of the reform (the main pad of Figure 1) is the concept of community, exemplified by our Catamount community service-learning component, which constitutes the focus of the current paper. The idea is that each incoming class adopts a small town (or towns) in Vermont interested in working with civil and environmental engineering students on real-world engineering projects. Throughout their tenure at UVM and in numerous engineering courses, students will work on service-learning projects with their town. By service learning we mean service learning as outlined by Furco (1996) and followed by others, that emphasizes the equal focus on both the service being provided and the learning that is occurring. The principles set
forth by Howard (1993), provide an excellent guide for ensuring successful service-learning projects and will be followed in our projects. A sense of community will also occur at the departmental level, expanding to these across-the-curriculum service-learning activities with Catamount communities, thus providing students with multiple, first-hand opportunities for studying and solving real-world, complex problems. A strong sense of community for our students and faculty creates a supportive, exciting environment for learning, and fosters the development of crucial technical and non-technical skills. Establishing student communities has been demonstrated as a way to increase retention in undergraduate engineering programs (Ohland and Collins 2002). Working with Catamount communities in a service-learning format will allow students a mechanism for constructing and personalizing a true systems approach to problem solving. We believe that integrating social and environmental components into our curricula will be a means for increasing social, racial, gender and intellectual diversity within our programs and thus serve as a model for other engineering programs.

Figure 1 also shows the essential tools and skills that engineers need to solve today’s complex problems. These include systems analysis, Information Technology (IT) applications, inquiry-based learning (IBL) and personal/interpersonal (P/I) skills also called “soft” skills. Systems analysis is a branch of systems thinking that deals with decision making and optimization of social and technological systems. Information Technology (IT) is an essential tool that is important for engineers and included in our reform. Inquiry-based learning (also called research-based learning) focuses on open-ended problem solving. Finally, Personal/Interpersonal (P/I) skills, also called “soft” skills, include teamwork, communication, leadership and other personal/interpersonal skills needed by engineers, especially in dealing with large, complex projects.

These tools and skills will be infused into out curricula by repackaging and reformatting some of our existing courses. For example, (i) the first-year Introduction to Civil and Environmental Engineering course incorporates a significant service-learning experience and discussions on ethical responsibilities of an engineer; (ii) existing courses (Engineering Economics, Transportation Engineering and Introductory Environmental Engineering) have recently been reformulated into a series of three Systems courses to emphasize the interconnectedness of infrastructure development, environment and economics and will be implemented into the curricula in the next two years; (iii) courses such as Geomatics, Materials, Hydraulics and Soil Mechanics will better integrate IT, inquiry-based learning and service learning as appropriate; and (iv) the senior capstone design course and many design electives have been redesigned to incorporate significant service-learning components. These courses include projects, reports and presentations conducted in a group setting promoting personal/interpersonal skills. Our goal is to reform our curricula along these lines and satisfy the ABET requirements without adding addition course requirements nor increasing the number of program credits. It is envisioned that the students will have at least one Catamount community service learning experience per year. Although these skills are crucial for successively adopting a systems approach to problem solving the remainder of the paper will focus on describing how the Catamount Community service-learning projects are being integrated within the Civil and Environmental Engineering programs at the University of Vermont.
SERVICE-LEARNING

Service-learning is a form of experiential education in which students engage in activities that address human and community needs together with structured opportunities intentionally designed to promote student learning and development (Jacoby, 1996). Service-learning research has shown positive impacts on student learning and development, in areas such as academic and intellectual development, civic engagement, career development, ethical judgment, and personal/interpersonal skills.

Structured critical reflection is a key component of service-learning that should be included as part of the service-learning activity. The idea is to help students get more from the experience by reflecting, integrating and synthesizing the experience with academic goals of the course, as well as personal/interpersonal goals and civic engagement goals. Clayton and Day (2003) suggest that during reflection activities students describe the experience objectively, analyze the experience from the aspect of personal/interpersonal goals, academic goals and civic engagement goals, and articulate the actual learning and why it is important. Reflection journals, papers, discussions and presentations are examples of ways that students can make the service-learning experience more meaningful.

A few years ago, the University of Vermont started the Community-University Partnerships and Service-Learning (CUPS) Faculty Fellows Program and Training Workshops in Service-Learning. The faculty fellows program is a weeklong service learning training program for UVM faculty with a focus on application to current courses that the faculty members are teaching. Not only do faculty members learn about service learning, they develop strategies for how to apply it to their specific courses and course needs. In addition, the CUPS office offers a variety of seminars and shorter workshops for UVM faculty. Two of the authors are faculty fellows and all members have attended various workshops on service-learning.

Service-learning projects are not new at UVM, and over the years have been incorporated into various civil and environmental courses (e.g. foundations design class worked with local nonprofits, Shelburne Farms and the Preservation Trust of Vermont; hazardous waste management class worked on pollution prevention projects (Figure 2); and our senior capstone course are currently working with a local nonprofit, Recycle North, and the City of Burlington for their design projects). The focus of the NSF Catamount Community grant is to integrate service-learning throughout the curricula and in such a way that students and faculty build strong relationships with local communities. We believe this integrated service-learning experience is key for really learning the systems approach to civil and environmental engineering problem solving that we are focusing on in our curricula.

Figure 2. N. Hayden with hazardous waste class working on pollution prevention service learning projects (UVM 2005).
CATAMOUNT COMMUNITY PROJECTS

The incoming class in fall 2005 is our first official Catamount community class. As part of our first-semester first-year Introduction to Civil and Environmental Engineering course, students investigated fourteen surrounding towns as potential Catamount communities. This course, with 55 students, is a relatively large when compared to other UVM engineering courses taken at the sophomore, junior and senior levels. Classes that are large logistical challenges when attempting service learning activities. Some of the difficulties were overcome by having students work in teams and providing ample class time for team meetings. Fourteen teams comprised of four students per team and some initial contact information was provided to the students. The overall goal was for the students to investigate communities in Vermont and some of the planning and engineering challenges that face them. These challenges are often the result of increasing population pressures as more people move into these once rural areas. Students gathered information about these towns by going to websites, finding information in the library, contacting local community members (e.g. town engineers, town clerks, selectmen), and visiting towns when possible.

Successful teamwork was both a course goal and project goal, so students were required to write team contracts, define roles and goals, complete team and self assessments, and perform other team activities. Final written reports and oral presentation were required. The format for the final report was as follows.

1. Introduction – This section included information about the town, maps related to town. Demographics. Contact person and credentials.
2. Challenges - This section outlined the engineering and planning challenges of the town and provided brief descriptions/details of why these are challenges. A concept map was included to show how these were related.
3. Engineering Component(s) –This section outlined the details of one (or more) specific challenges the town faces, including the what, when, where, why, hows and in terms of possible solutions: what, when, where, how, why.
4. Summary or Conclusion – This sections summarized main points or makes concluding remarks.
5. References – Proper citation
6. Appendix – This included information collected about the town, phone conversation documentation, and other “raw” data.

The results of this initial introduction to Catamount communities were timely, as the major concerns of all the fourteen towns involved were stormwater, transportation, and town planning issues. Because of the September 2005 timing of the award what this first class actually did was not really service-learning, although it had some common elements. Nevertheless, the students were instrumental in making first contacts and providing information to use in subsequent classes. They also learned soft skills in terms of teamwork, decision making and communication.

EVALUATION AND ASSESSMENT

The research method employed for the formative assessment part of the NSF project is a mixed-method research design. Qualitative research methods determine how changes in the civil
and environmental (CEE) programs as a result of the NSF project occur. Document analysis of student assessment ascertains how student learning is affected, and survey methods reveal attitudes and efficacy of undergraduate CEE students. The overarching research questions guiding the educational research part of the project are:

a) How do the CEE faculty work to enhance their program and curricular plans?
b) How do CEE faculty teach a systems approach for engineering problem definition and solution to students?
c) What is the role that service-learning plays in curricular reform and how does that impact students, faculty and the programs?
d) How do the changes in the civil and environmental engineering programs influence students learning and efficacy?
e) Is there a change in student retention in the civil or environmental engineering programs as a result of implementing this change?

To determine how CEE faculty work to reform their program, planning meetings and discussions are observed and participant observation field notes are taken. Easton’s System’s Analytic Framework (Wirt and Kirst, 1997) is being used as a framework to code the data.

To understand how CEE faculty teach a systems approach for engineering, we first collected baseline data of how current civil and environmental engineering courses are being taught. Observations of CEE faculty teaching Introduction to Civil and Environmental Engineering, Transportation Engineering and Hydraulics occurred during fall semester, 2005. These classes were videotaped and transcribed. Additional courses are currently being observed including Engineering Economics and the Senior Capstone Design course. Observational data that occurred during the academic year 2005-2006 provides baseline data to determine the extent of the changes in how undergraduate students were taught engineering topics. The baseline course observation data also provides a contrast to the implementation of core course changes that use a systems approach for teaching engineering. CEE faculty responsible for teaching the core courses in the program were interviewed and observed to determine their ideas for effective engineering teaching and learning. The Reformed Teacher Observation Protocol (RTOP) served as framework to code these data. Evaluations of in-class assessments and syllabi also served as data to determine changes in the CEE program and teaching.

Assessment on student learning and student efficacy as a result of curricular changes are being conducted. A first-year student experience survey was implemented in the beginning of 2004. We have also collected samples of undergraduate student work to determine what students are learning about civil and environmental engineering topics. These data will be compared to normalized gains from in-class assessments and longitudinal survey data after civil and environmental engineering program reform has been implemented. Quantitative attitudinal and learning surveys are also being developed to implement this spring. We have collected baseline institutional data on recruitment, retention, GPA, SAT scores, and student demographics do help determine retention rates of women and minorities.

**FUTURE WORK**

Our project started in the September 2005, so most of our work with curricular reform is still to come. In terms of Catamount communities, we will be working with several communities in two courses next fall, a sophomore level Geomatics course that has a significant GIS
component, and the first-year course with a more focused approach to working with communities. The students in next fall’s sophomore class are the students that started everything last fall. It will be exciting for them to get to actually work on projects with the different communities that they researched and contacted. These sophomore projects will be GIS related and pertinent to planning, stormwater and transportation issues. One or two communities will also be working with the first-year students. Because these first-year students are just starting their engineering education careers, their projects will focus on planning issues and gathering pertinent information for the communities, and will lay the groundwork for future activities.

In several of our senior and junior design courses (e.g. water and wastewater engineering, senior capstone course), we will continue to work with local communities and nonprofits so that these students also get the advantage of service-learning experiences. Although these students will not benefit from the continued service-learning integration that new students will, they will nevertheless get some exposure to service-learning opportunities.

WORKS CITED


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**ADDITIONAL REFERENCES**


AUTHOR(S) BIOGRAPHY

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