AC 2007-1910: USING A SERVICE-LEARNING PROJECT TO MAKE PROGRESS ON BOTH RECRUITMENT AND RETENTION OBJECTIVES FOR AMERICAN INDIAN ENGINEERING STUDENTS

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Using a Service-learning Project to Make Progress on Both Recruitment and Retention Objectives for American Indian Engineering Students

The Designing our Community (DOC) program at Montana State University (MSU), which is supported by the William and Flora Hewlett Foundation, has three goals: (1) Increase the motivation and pre-entry academic preparation of American Indian students who want to study engineering, (2) Help shape the engineering, engineering technology, and computer science workforce by increasing the number of American Indian students graduating from the College of Engineering, and (3) Improve access to quality engineering and technology to rural and underserved populations by returning highly educated professionals to these communities. Objectives relating to these goals include increasing awareness of career opportunities in engineering and increasing awareness of the contribution that engineering makes to quality of life.

We have developed many different ways to reach our goals and objectives, including a new approach we piloted spring 2006: a service-learning project in our required one-credit seminar for American Indian students. Students in the class were vertically integrated in groups to develop an engineering-related activity that could be used by 5th to 8th grade teachers to teach Montana math standards. In this paper, we discuss the curriculum for the service-learning experience, give examples of activities that the student teams developed, and report assessment results from the pilot test. We are convinced that this approach provides benefits not only for our American Indian engineering students, but also may interest 5th to 8th grade students in studying engineering.

Background and Rationale

The seminar component of the Designing Our Community Program requires students to enroll in a one-credit seminar every semester patterned after the broader concept of "learning communities." This is designed to increase student connectivity and to enhance student retention. The seminar has been designed to contribute to the following program objectives:

- Raise awareness of the connections between engineering and the quality of life.
- Enhance the sense of community for Native American students in the College of Engineering.
- Raise awareness of the various Montana State University support systems and resources.

- Expose Native American students to internship possibilities, particularly those in Native American owned engineering industries and in government agencies such as the Indian Health Service (IHS)
- Increase understanding of what engineers do and how engineering is connected to society and the quality of life.
- Raise awareness of career possibilities in engineering, including those that would allow students to return to their communities.
- Expose students to Native American engineering role models.

With once weekly seminars as a vehicle for regular contact, we establish a positive, fluid, learning environment to encourage students to provide academic and social support for each other, learn how to seek out and benefit from faculty assistance, and form study groups to prepare for classes, exams, and review the results of exams. For new freshmen and transfer students, the seminar serves as an introduction to college expectations and resources at Montana State University.

After the first two semesters of the DOC program, we wanted to revamp the seminar to engage our upper-division students who had already successfully completed the course and to eliminate the repetition of the content. In order to integrate all of our Native American students, from different disciplines within the College of Engineering and at different levels of degree completion, the Assistant Director of DOC introduced the service-learning theme for the seminar each Spring semester.

There is much evidence to support the positive impact that service-learning projects have on engineering education across disciplines and with engineering students at all levels. Service-learning projects that involve work with K-12 students and teachers are popular for introduction to engineering courses. Faculty at the University of San Diego in 1998 introduced service-learning into a first-semester engineering course in which students worked to produce a hands-on educational activity in engineering. Although some students were initially resistant to the idea, most students reported the projects helped them learn about communication and working together as a team. (Oakes et al., 2002)

We adopted a similar approach with our K-12 service-learning project as our students created and administered engineering activities based around middle school math content standards and benchmarks. Engineering educators have dual purposes in mind with K-12 service-learning projects. Thompson and Oakes note that service learning pedagogy integrates engineering in societal context, includes communication, employs cooperative and interdisciplinary approaches, and takes a holistic or global scope to problems. (Thompson and Oakes, 2006) Many of these qualities are attractive to both women and minorities in retaining them in technology and engineering. K-12 service-learning projects also allow meaningful outreach to take place, which will continue to feed the pipeline of new students into engineering fields.

Much discussion exists among educators about the affect of service-learning opportunities on attracting and retaining minority students into engineering fields. At the University of South Alabama between 1995 and 1998, service-learning projects were used in an introduction to mechanical engineering course. In the Fall of 1997, service-learning projects were introduced for the purpose of student retention into courses that target students who are in remedial math courses prior to engineering curriculum. Results indicated that students who enrolled in the service learning course are retained at a higher rater than those students who did not take the course. (Duffy et al., 2000) Not much data exists, however, on increased retention rates of minority students involved in service learning projects. Meadows and Jarema believe that characteristics of service-learning projects provide altruistic reasons for more women and minority students to be attracted to engineering. "Service-learning, particularly if offered early and throughout the curriculum, can play a significant role in the recruitment and retention of underrepresented students. (Meadows and Jarema, 2006, p.3) These concepts and an impetus for increased retention and professional development of more Native American engineers provided a strong argument for implementing our service-learning seminar.

Curriculum for a Service-learning Project

Student groups in this service-learning seminar produced a lesson for a middle school math classroom on topics in engineering. Service-learning course objectives state that after completing the course students would be able to:

- Effectively communicate to a live, non-technical audience.
- Complete a project as a team.
- Creatively design and implement an activity focused around content standards in middle school math.
- Have a better understanding of engineering related topics.
- Understand the significance of service-learning, and how it affects strength as a person and as an engineering/computer science student.

The first two weeks of the service-learning seminar focused on team work and ice breaker activities including an assessment of personal styles. In the next three weeks, students discussed and reviewed National and Montana math content standards along with math curriculum for 6, 7, and 8^{th} grade. The instructors modeled an activity for students that matched a math standard and incorporated a common engineering problem. Student teams were organized around level in school, major, and personal styles. We assigned each group a Montana math standard for grade 8, along with specific benchmarks. Students began brainstorming and outlining their activity by week five. Presentations by students to the class began in week seven and were completed by week fourteen.

A unique and important piece of service-learning curriculum includes student reflection in regard to themselves, group members, and their work. Students kept

a journal, and writing assignments were given throughout the seminar course. Students were initially asked to reflect on their personal style with regard to future work within their group. Throughout the development of activities, students kept notes on brainstorming and draft activities. Midway through the projects, students reflected on what attracted them to engineering as well as anyone that was influential in their math and science courses. Students incorporated this information into their activity as a way to introduce and tie their activity to engineering. As students presented their activities, they evaluated each other using a rubric that scored each activity based on categories previously outlined. Evaluation of each activity was done by classmates and by the instructors. Finally, students wrote reflections on their work and their team members toward completion of the activities.

Examples of Activities Developed by Students.

The groups completed six projects. In this paper we discuss one of the best activities and some general trends and difficulties faced by teams.

One of the most original activities was put together by a team of Civil Engineering students lead by a student in Mechanical Engineering Technology. The activity was entitled "Gravity Works" and involved students designing a ramp using plastic plumbing pipe. Students were given a length of flexible pipe and several sizes of marbles and ball bearings in order to experiment with height and mass as they relate to speed and gravity. The team believed they were using a visual, hands-on activity to explain a more complex concept.

Students from this team expressed frustration about how difficult it was to find an activity that incorporated math and touched on engineering topics. Students also expressed that the math standards as stated were vague, a common frustration among all groups. A student participant commented, "Service-learning in this case has been something that has made me get out of my comfort zone and step into somewhat of a leadership position in my group. Leadership is not something that really comes naturally for me so this was good." Most students, when asked to reflect on their own skills, expressed a need to improve their communication and teamwork skills, both of which were highlighted by this type of service-learning project.

Assessment Results from the Spring 2006 Seminar

Twenty one students completed an end-of-semester survey geared toward determining if the course met its objectives. We asked students to indicate their level of agreement with several questions about their service-learning project. The scale was a 5-point scale, with "0" representing "Strongly Disagree" and "4" representing "Strongly Agree." The averages of the responses are shown below. All 21 students responded to these questions.

	Average
The service-learning project improved my ability to communicate to a non-technical audience.	2.86
The project improved my ability to work effectively with a team.	2.81
The project increased my understanding of how engineering can be integrated into middle-school curriculum.	2.90
The project increased my understanding of the technical side of engineering.	2.43
The project increased my appreciation for how I can contribute to the community.	2.76
The project increased my confidence that I can be successful in an engineering career.	2.52

We also asked them, "What is the most important thing you learned from the service-learning project?" Ten of the responses mentioned teamwork, and five commented learning about how to adjust engineering activities to a younger audience.

Implementing the Service-Learning Activities

The service-learning project culminated with student groups demonstrating their activities on real life middle school students. We originally planned for student teams to go into a middle school math classroom and "teach" their activity as a team. We were unable to implement this plan because of the difficulty in every student's schedule meshing with traditional school day schedules. Instead, we were able to take advantage of a university holiday in November (Election Day) to have students present their activity to an after school program at the local Boys and Girls Club. The audience at the Boys and Girls Club ranged from 4th graders up to 8th grade students.

All of the students had the opportunity to try out their activity with a range of students, adapting to the age of students as appropriate. Each group taught their activity for 20 minutes and then participants were rotated through in small groups. Over 40 students from the Boys and Girls Club participated in our "engineering" activities developed through this project. The student teams had to adapt their teaching and their activity in a traditionally non-academic setting and to a wide range of student ages and abilities. The students adapted well and were able to interact and work with students in regard to their developed activities. As a side note regarding working with the Boys and Girls Club, many of the college students remarked that the club could use some more help and would be a good place to do another service-learning type of project.

Students participating in the November event with middle-school students were asked to respond to some of the same questions they answered at the end of the spring seminar. We asked students to indicate their level of agreement with several questions about their service-learning project. The scale was a 5-point scale, with "0" representing "Strongly Disagree" and "4" representing "Strongly Agree." The averages of the responses are shown below.

	Average
The service-learning project improved my ability to communicate to a non-technical audience.	2.75
The project improved my ability to work effectively with a team.	2.88
The project increased my understanding of how engineering can be integrated into middle-school curriculum.	2.88
The project increased my understanding of the technical side of engineering.	2.13
The project increased my appreciation for how I can contribute to the community.	3.25
The project increased my confidence that I can be successful in an engineering career.	2.25

Evaluation of Our Service-learning Approach

Our pilot service-learning seminar for our American Indian engineering students showed promise. We think that the approach has the possibility of benefiting not only the engineering students but also middle school students and teachers. We have found that service-learning projects build teamwork and communication skills and develop leadership skills and civic duty responsibilities; in addition, the projects may help to retain students in the engineering field because of the connection to helping people.

One of the positive outcomes of the approach is the contribution made to our goal of creating community for our Designing Our Community students. The vertically integrated teams worked together well, and the projects created a context for new students to work with our more seasoned students. It is difficult to measure the informal mentoring that occurred during the projects, but we are confident that all students benefited from working together in the project teams. In addition, students gained from critiquing the activities created by other groups. These oral critiques gave students practice in giving constructive feedback in a tactful way.

Another positive outcome is increased awareness of the role that the university (and, by extension, engineering students) plays in the community. Students

learned more about the Boys and Girls Club and about some of the challenges of teaching middle-school students.

The service-learning projects definitely presented some challenges. We had hoped that our engineering students would see the connection that the math applications had to engineering; however, the students struggled to see that connection. The middle-school students likely did not make the connection either. Another challenge was the varied age group (4^{th}-8^{th} grade) that we worked with. We hope to be able to work with a more limited age group in the future. However, the scheduling is difficult for both the college students and the K-12 classroom. In our case, we resorted to implementing the activities in a recreational setting. An academic setting would have provided more structure and, likely, a higher level of success.

We hope to address some of these challenges in our second iteration of the service-learning seminar in spring 2007. We will incorporate four different projects for the next service-learning seminar for spring 2007. Several of the projects will have a K-12 theme, including a project developing a hands-on module on engineering for the local Children's Museum. Changes we have implemented based on lessons learned from the pilot program include: training the students in communication, increasing project management skills by incorporating project charters, and instructing the students with teamwork and conflict management exercises. We will also include more faculty engineering advisors as well as community advisors in working with individual team projects. We also believe that better organized projects from the beginning of the program will allow us to target groups with appropriate projects and deliverables. We look forward to reporting on the results of our revised service-learning seminar.

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