Using Service Learning to Engage American Indian Students in Engineering

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Abstract
Service learning opportunities in engineering education are growing. The most notable examples include the Engineering Projects in Community Service (EPICs) program, which now has 17 participating universities around the world, and Engineers Without Borders (EWB), which boasts over 200 chapters working on 170 projects in 41 countries associated with engineering programs.

Service learning experiences can enrich the education of all students, but have the potential of being especially valuable for women and under-represented minority students in engineering. The Service in Engineering for Reservations Via Education (SERVE) program at Montana State University, funded by the U.S. Department of Education, is designed to enhance successful programs we have in place to recruit, retain, and graduate American Indians in engineering, engineering technology, and computer science degree programs. Most of these successful programs were developed under the broader Designing Our Community (DOC) program. With SERVE, we are leveraging our initial success with the Designing Our Community seminar for American Indian students by implementing a service learning component in the course. This service learning component gives students an opportunity to help solve a real-world problem with a community or service provider early in their engineering degree program.

Early evaluation of our SERVE efforts provides evidence that a service learning experience for our American Indian engineering students is contributing to progress toward goals of recruitment, retention, and professional development for these students. Preliminary results with American Indian students completing a service learning course in 2008 demonstrated a greater persistence percentage (82%) than those students that did not take a course (71%). In the future, engineering student projects to the various reservation communities could strengthen the relationships we are building with these communities. The service learning experience enhances student understanding of the real world value of engineering and how they could use their education to solve societal problems, including those on the reservations. Finally, working with people from the community on solving a problem gives students a better idea of what engineers do, and thus contributes to our goal of providing professional development opportunities for American Indian students.

DOC Program
Montana State University (MSU) College of Engineering's (COE) vision is to become the "University of Choice" for American Indian students seeking degrees in engineering, engineering technology and computer science. Much has been done over the past five years to

help reach these goals with the inception of the Designing Our Community (DOC) program in 2003, funded by the William and Flora Hewlett Foundation. The DOC program's main goals are to recruit, retain and graduate American Indians in the fields of engineering, technology and computer science. American Indians make up the largest ethnic minority in Montana, almost 12 percent of the K-12 population. As the land grant institution, MSU is responsible for providing education opportunities for all Montana's citizens. American Indians are underrepresented in career fields of engineering (less than .05 percent). DOC program objectives include the following:

- Increase the number, motivation, and pre-entry academic preparation of Native American students entering the engineering profession pipeline.
- Help shape the engineering, engineering technology, and computer science workforce by increasing the numbers of Native American engineering graduates.
- Improve access to quality engineering and technology to rural and under-served populations by returning highly educated professionals to these communities.

Two main goals of the DOC program are to increase persistence and provide professional development and leadership opportunities for American Indian students enrolled in engineering programs at MSU. To contribute to meeting our goals, we implemented a service learning project course for our students during the spring academic semester.

Service-learning and Native Americans
"Service is the rent we pay for living, the anchor to our humanity. It is about moral courage, not about being smart. Moral courage is about stepping forward, and I think everybody can do it-if they find their memory and find their song." (Norbert Hill Jr. (Oneida), 1991) Several well known Native American educators are utilizing service-learning to reinvigorate and empower education for young Native American students. Calvin Dawson administers the Learn and Serve America funding for Native American communities and helps projects link service-learning to tribal history, culture, community and place. Dawson writes, "The goal of service-learning is to encourage individuals--young and old alike--to take responsibility for their actions and to become effective contributors to their communities and greater society."(Dawson, 60) For example, in a project with the Fort McDermitt Paiute-Shoshone Tribe of Nevada, students worked with the tribe to direct an economic and community development program. As a result, students had increased attendance rates at school; in addition, the school reported greater parental participation in school events and a greater number of students reporting interest and involvement in social issues within their community.   Lynn LaPointe leads the Minnesota-based community partnership between the National Youth Leadership Council and the University of Minnesota programs Pathways to Possibilities and Outreach to Empower. Pathways to Possibilities is a college preparatory program that uses service-learning projects and math and science tutoring to increase high school retention and increases entry into post secondary education for Native American students. Their Outreach to Empower program works to keep at-risk Native American students engaged with school and promoting positive movement to post secondary opportunities through service-learning projects. "This reintroduction to a healthy model of community and service has been instrumental in the successful leadership development for all American Indian students who have been exposed to, and have embraced, service-learning

while participating in both (National Youth Leadership Council and University of Minnesota's) Pathways and Outreach programs."(LaPointe, 66)

Service Learning, Engineering and Retention
Engineering education has traditionally focused on developing students' strong technical skills. There has been a surge in the past several years by many national organizations and committees to reform the existing engineering curricula to include preparation of engineers for the broader future challenges of our world beyond the technical skills, including globalization, sustainability, complexity, and adaptability. Leadership, project management, teamwork, and communication have been identified as some of the important professional attributes of successful engineers in our world today. Engineers also need an awareness of the ethical, legal and environmental issues affecting any engineering project and the ability to work with people from many different backgrounds and in many social settings (Coyle, 2006). Compelling and meaningful applications of the technical knowledge enhance the education gained through the engineering curriculum. For many students, especially minority students, the altruistic nature of service learning and providing 'expertise' to the community motivates them to want to learn more: "If students are able to experience a tangible purpose and framework for fundamental courses they take during the first two years of their curriculum, they are more likely to be motivated and understand why they are learning the required material" (Lima, 2000, 112).

There are a few studies that have investigated service learning's impact on retention in higher education. Some studies have shown that participation in service-learning positively affects interpersonal engagement with peers and others at the university. Braxton, Sullivan, and Johnson (1997) noted that service-learning offers the conditions identified in Vincent Tinto's theory as most likely to facilitate developing meaningful connections between students, faculty, and community that will result in retention (Gallini, 2003). In looking directly at the impact of service learning on student persistence in college, Astin and Sax (1998) found that participating in service activities during college was positively associated with the student's satisfaction with the college. Muthiah et al. (2001) found that students who participated in service-learning felt their class had an influence on their persistence in college.

Gallini and Moely (2003) built on the existing research and hypothesized that "students engaged in service-learning would 1) score higher on community, academic, and interpersonal engagement; 2) rate their classes as more academically challenging than non-service learning participants; 3) indicated that their courses influenced plans to continue at the university to a greater extent than non-service-learning students; and 4) following Tinto's (1993) model, students' academic and interpersonal engagement would mediate the relationship between service-learning and retention" (Gallini, 2003, p. 6). The study included students from 17 courses representing nine academic disciplines in the liberal arts and science but did not include engineering students. These researchers demonstrated that participation in service-learning courses affects students' plans for continued study, and that the academic aspects of the service-learning courses, such as applying concepts, reflecting on the concepts, and developing a deeper understanding of course materials, are important in service learning's influence on retention (Gallini, 2003). Academic engagement and academic challenge were significant predictors of retention in this study. The findings indicated that service learning courses were viewed as promoting interpersonal, community, and academic engagement, and academic challenge as well as retention. Gallini and Moely concluded that academic engagement and academic challenge

were aspects of service learning that most influenced students' plans to continue to study at the university (especially for the first and second-year students).

Coyle, Jamieson, Oakes (2006), the founders and directors of the Engineering Projects in Community Service (EPICS) program, noted, "the learning via real projects also allows exploration of start-to-finish design, including problem definition, development of specifications, version control, design/coding standards, and rigorous testing" (9). The authors highlight two benefits to the mutual partnerships involved in service learning as:

- academic credit for engineering students via long-term, large-scale, real-world design projects that benefit the community; and
- access for the community partners to the low-cost technical expertise they needed to improve their capability to serve the community (Coyle, 2006, 7).

Like the EPICS program, service learning enables students to develop technical depth and multi-disciplinary breadth; experience start-to-finish design; acquire and hone many professional skills; create products that have a significant impact on their community; and grow as individuals, engineers, and citizens (Coyle, 2006, 7).

Service-learning Seminar
As part of the retention program in engineering at MSU, American Indian students participating in the DOC program are required to take a DOC program seminar course both Fall and Spring semester. Fall semester is targeted at new freshmen and transfer students (on average 10 students), and course subjects focus on enhancing study skills, building a learning community among the students, networking with upper-division American Indian students, and connecting with opportunities and people in the COE at MSU. Spring semester DOC students, freshmen through seniors, take the service-learning seminar. DOC service-learning seminar student objectives include:

- Utilize the skills of each team member to deliver a one-of-a-kind product.
- Refine the ability to communicate, plan, execute, and resolve conflict in a team.
- Have a better understanding of how engineering/computer science can meet society's needs.
- Network with peers, professionals, and mentors in a learning community.
- Evaluate personal and professional strengths and weaknesses.

Groups are vertically integrated and seniors are often assigned as group leaders for each project. Each semester, service-learning projects differ in topic, problem, and community provider. In Spring 2006, twenty one students developed a middle school math activity that incorporated engineering concepts and met Montana 8th grade math benchmarks and standards. Spring 2007, four different projects were assigned to four groups (nineteen students total): designing an engineering exhibit for the local Children's Museum, performing a study to help the local Boys and Girls Club better use gym space in a new building, and two projects involving preparing challenge fields for middle and high school For Inspired Recognition of Science & Technology (FIRST) regional championship tournaments.

In Spring 2008 we tried to develop projects that dealt with community issues at reservation communities in Montana. Three different groups of students (six students) worked with an engineer at our regional Indian Health Service in Billings, MT, on engineering projects at

reservations in Montana. Students spent the semester developing engineering projects for possible use in senior design projects in the COE. Native freshmen engineering students were able to foresee senior design projects and to develop projects out of issues or problems within their own communities. Six DOC students this past Spring, 2009, freshmen and sophomores, worked on a feasibility study for a large public high school on the Blackfeet Reservation. The Browning public school system built a new high school on their reservation and it is the largest majority Native American school in the state. Funds have been earned by the school district to promote and develop alternative energy resources for use by the new high school. Many school board members were not willing to jump into alternative energy without knowing more about costs and benefits. Our students decided to investigate uses of alternative energy on their own home reservations and write up general information for a report for the school board. The class was co-taught by two Native American seniors in mechanical engineering and civil engineering. They were able to lead the younger students through the process of project development and completion.

Preliminary Retention Results
Some preliminary results show a positive trend in persistence for those American Indian students who participate in service-learning courses in engineering versus those American Indian students who do not. As part of our analysis we compared American Indian students who successfully completed a service-learning seminar (SL) and those who did not pass or enroll in a service-learning seminar (No SL). Persistence for our data is defined as self-identified Native American students who occur in school data as enrolled from Fall to Fall semester. Our data reported for 2007 (Fall 2006 to Fall 2007) indicate that students who participated in service learning (SL) (21 students for Spring 2007) persisted at a rate of 76 percent. While those American Indian students who did not participate in SL (19 students) persisted at a rate of 68 percent. In 2008 (Fall 2007 to Fall 2008), American Indian students participating in SL (17 students for Spring 2008) persisted at 82 percent, while 71 percent (17 students) of those American Indian students who had not participated in SL persisted in engineering degree programs (Table 1).   We are careful to mention this data set is less than 50 students and only represents students at MSU and has not been evaluated for statistical significance. Data collection will continue, which will allow us to increase our sample size and to analyze for statistical significance.
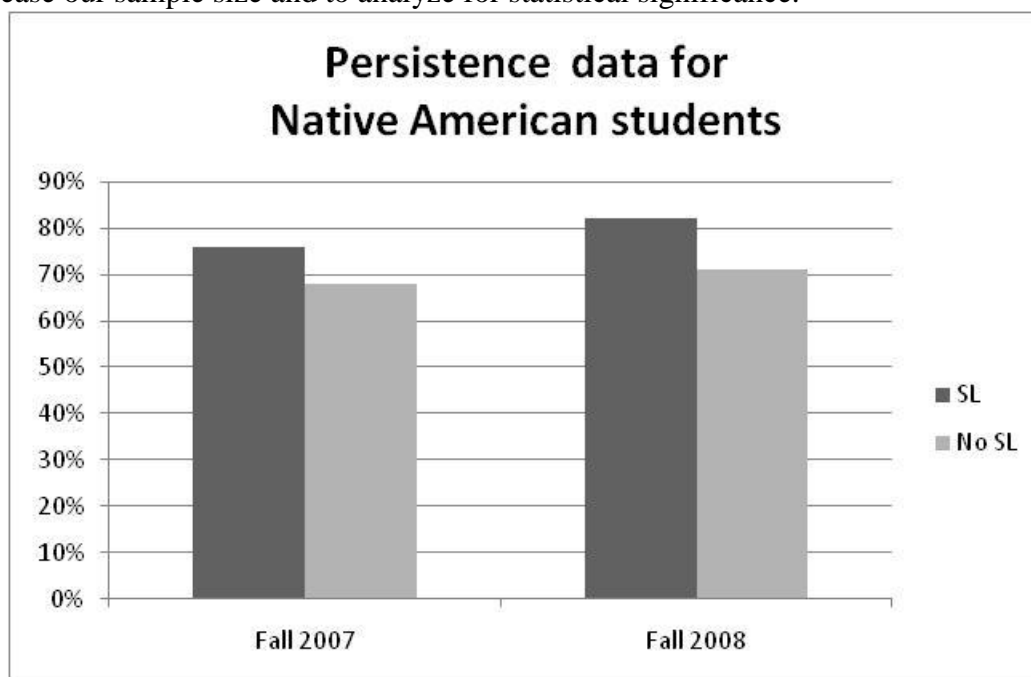

Table 1. Persistence data for Native American students from Fall to Fall in the COE.

SERVE Program Assessment

Each year, we survey American Indian students who graduate with an engineering or computer science B.S. and who were involved in Designing Our Community and SERVE programs. We use the survey to collect both qualitative and quantitative data, although the former is more useful because of our small samples. In 2008, four of five graduating seniors responded to the survey; in 2009, five of five responded. When asked what they learned from the service learning experience, students responded as follows:

- I learned that engineers can have a great impact on the rest of the community by applying their skills and knowledge.
- I participated in service learning program involving the FIRST VEX challenge. My group members and I built a course for students to compete in a challenge involving robots. The field was complete with a lazy-Susan platform and high goals that the robots had to put get on and put soft balls in respectively. I learned the importance of good team work through this activity. My group members and I worked hard on the project and felt as though the kids were counting on us to make our deadline of completion. A sense of accomplishment was felt the day of the VEX challenge when we were able to see the kids compete. I personally felt that I had helped the youth learn about science in a fun way and was proud to be a part of such a great activity.
- Teaching engineering to children is no easy task.
- Yes, I learned how to work effectively with both engineers and non-engineers. I also learned how I could use my engineering knowledge to contribute to my community.
- I learned about the resources on campus available to me such as financial advice, resume writing, and note taking.
- I also enjoyed meeting practicing engineers. The service learning portion made me more aware of the roles engineers can assume in a community.
- I went with several people to a high school to help with an egg-drop activity. It was cool to see kids try to creatively tackle the same problem from different sides.

When asked if they would recommend service learning to other engineering students, they responded:

- Yes, it is important to be generous to the world. If engineers were a larger part of humanitarian solutions and policies many problems would be solved faster, more sustainably and more cheaply.
- Yes. It is a good experience to actually work with community members.
- Definitely. As students we sometimes get stuck in the day to day chaos of trying to get school work done and begin to lose sight of why we chose engineering in the first place. Being a part of service learning helps the student relate to their future profession in a fun way. It puts the students' skills to [work to] do good for the community and there is a sense of joy that comes from that. In short, the service learning project is a wonderful way for

students to apply some of what they have learned in school to the real world while making a difference in the community. Every engineering student should experience this feeling multiple times while obtaining their degree
- Yes, it can make a person respect and realize the difficulty of being a professor/teacher.

Students are also asked to give us feedback at the end of the seminar each spring. At the end of the spring 2009 seminar, six students completed an end-of-semester survey geared toward determining if the course met its objectives. Six students also responded at the end of the seminar in 2008.

We asked students: "Did the seminar increase your understanding of how engineering contributes to society and the quality of life? If so, in what way?" Some of the responses from both 2008 and 2009 are below:

- Engineering plays a part in almost every aspect of life.
- [The seminar] displayed the social and ethical impact engineers have.
- It helped me understand some of the things engineers have to do.
- It showed many of the steps and procedures required in making projects run smoothly.
- How engineering affects so many people.
- We had real hands-on experience with something we may encounter in higher levels of schooling or in the real world.
- Practical application of engineering skills to solve health-related problems.
- By showing the process in which engineers figure out and solve problems.
- I did not know about so many reservations with problems with the water systems and now engineering makes a difference amongst communities.
- Helped identify the problems that I will have to overcome.
- Everything needs an engineering perspective.

Over the years, we have asked students to indicate their level of agreement with several questions about their service learning project. The scale was a 5-point scale, with "1" representing "Strongly Disagree" and "5" representing "Strongly Agree." The average of the responses is shown below.

	Mean 2006 n=21	Mean 2007 n=19	Mean 2008 n=6	Mean 2009 n=6
The service learning project improved my ability to communicate with team members and resolve conflict within a team.	N/A	N/A	4.50	4.33
The project increased my appreciation for how I can contribute to society as an engineer.	3.76*	4.37*	4.33	4.17

The project increased my understanding of the technical side of engineering.	3.43	3.53	4.17	3.83
The project increased my understanding of typical senior design projects.	N/A	N/A	4.67	4.00
The project increased my confidence that I can be successful in an engineering career.	3.52	3.74	4.17	4.33
The project increased my appreciation of the value of networking with peers, professionals, and mentors.	N/A	3.95	3.67	4.33

*Previous year's question: The project increased my appreciation for how I can contribute to the community.

Although these results, particularly those of the last two years, are based on a small sample of students, they show a fairly consistent and positive perception on the part of these students toward the service-learning experience.

Perhaps more valuable are the students' open-ended responses at the end of the seminar. When students were asked, in spring of 2009, "What is the most important thing you learned from doing this service-learning project?", they responded as follows:

- Just how engineering plays a part in everyday life whether you notice it or not.
- What engineering impacts on a possible social level.
- How to write a feasibility study.
- What it takes for a simple project.
- How to work in a group to help a community.
- Communication is something we definitely need to know how to do amongst ourselves and project managers.

When asked "What did you learn about effective teamwork from the service learning project?", students responded:

- When all of the team members do their job, things go pretty smoothly.
- [Teamwork is] necessary for project success.
- Teamwork is important to completing a project.
- Effective and cooperative teamwork is vital for a project running smoothly.
- Helps.
- It is definitely hard to get everyone together and focused, but once we do, we can accomplish a lot.

Thus, input from students, both immediately following the service-learning experience and later upon graduation shows that the students are, for the most part, responding positively to the experience and gaining a richer understanding of the value of communication and teamwork as well as the contribution engineering can make to the community.

Conclusion

We report in this paper some preliminary results of a service-learning course as a piece of a program to recruit, retain, and provide professional development for American Indian students in the DOC program in the College of Engineering at Montana State University. It has been shown by American Indian youth educators that service-learning projects can help motivate, connect and promote further education for young Native students. Based on our qualitative responses collected at the end of each seminar we observe a positive response from our Native students in regard to working on a real life project with real community partners. They appear to observe the role engineering can play in society and strengthen their belief in their abilities to help people as an engineer. These responses mirror the motivation and involvement in societal issues that were observed in Native youth experiences with Dawson and LaPointe. American Indian students in our seminar also believed they gained experience in communication and teamwork skills, which will help them succeed in further engineering coursework.

Secondary are the tangible experiences gained from service-learning courses, which can provide motivation for students to persist in higher education. We have observed in responses to surveys that students enjoyed working in peer groups, particularly with upper-division students. Upper-division students comment that talking and working with lower-division students allows them to provide some guidance, which lower-division students are eager to accept. Service learning in the DOC program provides a vehicle for developing meaningful connections between students, faculty and staff, which according to Vincent Tinto's work will result in increased retention. We have revamped the service-learning course the past two years to include freshmen and sophomore level students and use our upper-division students as co-teachers and mentors. Our most current service-learning projects collaborate with partners from Montana reservation communities. These types of home grown experiences may provide motivational experiences similar to those seen with Dawson and LaPointe in regard to young American Indians taking more responsibility and leadership within their own communities.

Finally, we understand this is a small sample size at only one institution. However, our findings are aligned with much of the research that exists on the impact of service learning, especially on under-represented groups of engineering students. Our initial analysis of American Indian students participating in our service-learning seminar shows a slight positive trend for participants versus those who do not participate. These students also participate in a retention program with DOC and so receive mentoring, supplemental instruction, student center networking, and extra advising, which may compound the positive effect we see from service learning courses. We will continue to collect persistence and survey data in order to more fully understand the effect of service-learning on student persistence.

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