Service Learning in Engineering

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ABSTRACT

Although engineers contribute much to society, most engineering undergraduates do not see this aspect. Engineers can, and do, provide much service to the community and world. A service-learning course in engineering helps students to be aware of their personal, as well as the global, contribution of engineers. The Wichita State University College of Engineering has initiated the Engineer of 2020 program, which must be completed by all undergraduate students. One of the six potential criteria for this program is service learning. The objective of developing a course that provides a service learning experience is to expand each student's perspective that engineers can have a positive impact on their community and the world. This paper presents the motivation, content, and the assessment process of such a course.

MOTIVATION

The College of Engineering (CoE) at Wichita State University (WSU) has a very active Industrial Advisory Board (IAB) that recommends our graduates have a competitive advantage that includes more than just the technical skills of an engineering degree. CoE faculty and the IAB have launched a strategic initiative, Engineer of 2020, in order to prepare graduates for effective engagement in the engineering profession in the year 2020. This initiative is in part motivated by two reports from the National Academy of Engineering, of the National Academies, entitled The Engineer of 2020 [1] and its follow-on Educating the Engineer of 2020 [2]. These reports, written by two groups of distinguished educators and practicing engineers from diverse backgrounds, were developed in response to a concern that engineering students of today may not be appropriately educated to meet the demands that will be placed on the engineer of the future without learning institutions refocusing and reshaping the undergraduate engineering learning experience.

A number of noted engineering education leaders have responded and commented on these reports. Butcher claims the reports call for, "ingenious leaders — ingenious engineers" and calls these engineers, "well-rounded Renaissance Engineer"[s] [3]. Turns, Atman, et al., [4] use these reports as an input to what an engineer needs to know. Dym, et al. present how engineering education is being challenged to require students to consider additional design constraints required as part of "new fundamentals" [5]. In response to this challenge, the CoE at WSU is a leader in reshaping the undergraduate experience to prepare the engineer of 2020, and at the same time make the educational experience more meaningful to the student and the student more desirable to local and national industries. As such, the CoE requires that for an Engineering BS degree at WSU, each student will complete the program course requirements and at least three of the following six activities:

1. Undergraduate Research

2. Cooperative Education or Internship
3. Global Learning or Study Abroad
4. Service Learning
5. Leadership
6. Multidisciplinary Education

Previous papers have described global learning efforts (Whitman, et al. 2009) and Leadership (Malzahn, et al. 2010). The complete WSU CoE plan for, "The Engineer of 2020" was also reported (Whitman, et al. 2007). This strategic initiative takes advantage of the flexibility of the new Engineering Criteria 2000 (EC2000) of the Accreditation Board for Engineering and Technology (ABET), and helps the programs offered by the College to satisfy the criteria and spirit of ABET EC2000. The criteria that each activity may satisfy and the linkages to the Engineer of 2020 are shown in a subsequent section.

Service Learning in Engineering

The literature is full of service learning in engineering courses developed by other colleges of engineering indicating that the approaches to service learning are varied. The external stimuli for the development of this type of course may point to the difficulty of identifying faculty and departments that view this topic as being within their expertise. Service learning is not typically part of an engineering faculty member's graduate training. Most faculty have not even heard of service learning or, even worse, they have a bad impression (volunteerism). Astin, et al. (2006) performed a study with a national cohort of students and found that service learning had significant impact on student outcomes. Oakes (2004) describes in detail those universities doing service learning in 2004. Duffy, et al. (2009) also reported positive outcomes on many of the ABET (a-k) criteria. Borrego et al. (2010) reported results of a survey showing that, "…79 percent of department chairs had heard of service learning, only 23 percent of departments currently offered it."

Several service-learning definitions are now presented. Jacoby, et al. (1996) defined service-learning in general, as, "…"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. Reciprocity and reflection are key concepts of service-learning." Duffy, et al. (2009) stated that service-learning is "… a hands-on learning approach in which students achieve academic objectives in a credit-bearing course by meeting real community needs." At WSU, the definition of a service learning activity is broadly described with three aspects:

- an educational experience that is course-based and credit-bearing;
- an organized service activity consisting of an intentional and thought-provoking application of classroom learning to active and engaging work by participating in a group project that meets identified community needs;
- structured reflection on the service activity to gain further understanding of course content, a broader appreciation of the discipline, and an enhanced sense of civic responsibility (Bringle & Hatcher, 1995; Totten & Pederson, 1997).

In the context of the class, a ”community” is broadly defined and opportunities for service can address a wide variety of community needs.

The next section provides an overview of the course purpose, course content and assessment.

COURSE DESCRIPTION

ENGR 202, “Service Learning in Engineering” is an undergraduate one credit hour course. It is scheduled for a one-hour period once a week. Service learning in engineering is an intentional and thought-provoking application of classroom learning to active and engaging engineering work by participating in a group project that meets identified community needs. The course is project-based, with a report and reflections. The project is identified by the student from a list of options such as mentoring or leading a team of students in an engineering service effort. Typically, the faculty provides a set of options for the project and the student selects the option that best fits the student’s objectives and schedule.

To satisfy the curricular requirements of Service Learning, each student completes one of the following:

1. A project that meets the criteria of service learning as a semi-major component of a one-semester, for-credit existing course. For example, two existing courses that could have service learning options are Engineering 101 and the Senior Project.

2. A one-semester, for-credit Independent Study course that meets the criteria of service learning. Each student enrolls in the Independent Study course of their major, and works in multidisciplinary, cross-College teams. Each student has a faculty mentor from their home department.

The projects have typically been of two different types: 1) mentoring or 2) leading the design and build of a LEGO Robotics course.

The mentoring has been in many different types as well. Some examples are students mentoring a LEGO robotics team, mentoring a BEST robotics team, and mentoring a young student as part of the Big Brother Big Sister (BBBS) program. Each of these are further described in the next several paragraphs.

LEGO Robotics – For students to mentor a LEGO Robotics Team, the student must become familiar with LEGO Robotics and the LEGO Robotics software. The student mentor meets with their assigned robotics team once a week during the semester. This is IN ADDITION to class time. Students are requested to carry on in mentoring the team through the competition (in mid-March). The students mentored are in 4th through 8th grades. More details about the Shocker MINDSTORMS competition can be found on the website: http://www.wichita.edu/mindstorms).

BEST Robotics - For students to mentor a BEST Robotics Team, the student is encouraged, but not required, to become familiar with robotics or the programming software. The student mentor meets with his/her group once each week during the semester and through the competition

(early-November). This is IN ADDITION to class time. The students on BEST robotics teams are high school students. More details on BEST can be found here on the website at: www.kansasbest.org.

Big Brothers Big Sisters (BBBS) - BBBS mentoring focuses around a partnership with Big Brothers Big Sisters Great Expectations in Math and Science (GEMS) program which is a special mentoring program designed to foster children's enthusiasm for math, science and engineering. Student mentoring responsibilities include mentoring a child at a nearby elementary school by sharing his/her design knowledge and skills in utilizing math and science. To participate in this type of mentoring, the student must agree to a background check and participate in a short interview with a staff member from Big Brothers Big Sisters. Students go to an elementary School once a week either during lunch or after their school day to meet with an elementary school student. This is IN ADDITION to class time.

LEGO Robotics Course Design - The leading of designing, building and running a LEGO Robotics course requires the student to learn about LEGO Robotics and complete two of the "apprentice courses." Student mentors use the engineering design process as they design a course to a specified theme (for 2011 it was a sustainability theme entitled, "Saving the World: One Brick at a Time"); have the design approved; build the course; have the course build verified against the course design; and run the course on trial and competition days.

ASSESSMENT

The types of assessment are related to the assignments for the class. Students must complete a journal – where they discuss the engineering process and how it applied to their efforts; reflections –where students discuss their observations after an activity (more details on this later), presentations on what worked and what did not work; and some specific assignments related to the specific requirements for the service learning area selected by the student.

Many engineering students actually do very little writing (especially, non-technical writing) in their junior and senior years. Many engineering students are also unfamiliar with using a rubric to guide their writing. Students tend not to think critically about their own writing. These students believe they are already "good" writers and that writing assignments are "easy A's." that is why the assignments receive low weighting early in the semester and receive increasing weightage throughout the semester. Students are provided feedback as to their reflective assignments that allow them to improve their writing on subsequent assignments. The grade is not reflective of their grammar and spelling, but rather the reflective nature of their writing.

A key component of this class is the reflective writing. The next section describes the purpose of the reflection, the grading rubric, and some common difficulties with the writing.

Reflections

A key part of what makes service learning an activity worthy of college credit is its reflective nature. The reflection rubric evaluates four areas: *evaluative thinking* (the excellent rating is when students use information to support beliefs and indicates a need to gather more info to

further support beliefs); *divergent thinking* (the excellent rating is when students demonstrate that they organize available relevant information into viable framework to achieve goal and obtain additional relevant information to create plan towards goal); *convergent thinking* (the excellent rating is when students provide interpretation and analysis of information from multiple perspectives and present new perspectives using additional relevant information); *cognitive memory* (the excellent rating is when students apply a range of relevant information to validate and the validation based on additional relevant information).

As mentioned previously, students did not refer to the rubric when writing and thus, these areas were typically not addressed. After the first two reflections, students began to identify limitations, but still had difficulty addressing them. Students consistently had difficulty with how to validate that what they were doing was of any real value.

Reflective writing was a key component of the course, and it appears that it is had an impact on the students. Students are more aware of their attitudes and can think about engineering in broader context. Several students have commented on how this class made them more aware of how engineering can impact their community as well as how to present engineering to a non-technical audience.

SUMMARY

Wichita State University's College of Engineering has implemented a new program called, "The Engineer of 2020." This program requires students to complete three of six criteria identified by the National Academy Report, "The Engineer of 2020." One of these criteria is service learning. This paper presented several definitions of service learning, proposed a new definition, discussed a classroom implementation, and a reflection rubric.

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BIOGRAPHICAL INFORMATION

Lawrence E. Whitman is the Director of Engineering Education for the College of Engineering and an Associate Professor of Industrial & Manufacturing Engineering at Wichita State University. He received B.S. and M.S. degrees from Oklahoma State University. His Ph.D. from The University of Texas at Arlington is in Industrial Engineering. He also has 10 years experience in the aerospace industry. His research interests are in enterprise engineering, engineering education and lean manufacturing.

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