Service-Learning as a Driving Force for Continuous Improvement in CCE 1001, "Introduction to Engineering Design"

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Abstract

Service-learning has served as a driving force for continuous improvement of CCE 1001, "Introduction to Engineering Design," which is a first-year course on engineering design for civil and construction engineering students at Western Michigan University. The motivation for incorporating service-learning into CCE 1001 is initiated by the department chair and faculty to support the Program Educational Objective of "graduates use profession to contribute to society through service to the community." The community partners include the Michigan Department of Transportation and K-8 schools, and the federal program, Safe Routes to Schools (SRTS), serves as the service-learning design project for CCE 1001. Preliminary results show students improving oral communication skills and gaining awareness of the factors contributing to poverty through the SRTS project.

Introduction

CCE 1001, "Introduction to Engineering Design," is a first-semester course that has served as the anchor class of a learning community for civil and construction engineering (CCE) students since 2005 at Western Michigan University (WMU), a state regional university in Kalamazoo, MI. Students in a learning community take the same 3-to-5 classes together in fall semester and the same 2-to-4 classes in spring semester. By progressing through the first year of college as a cohort, students are able to build connections with each other and form study groups, in addition to other benefits that ease the transition from high school to college. Details on how the STEP learning communities are constructed for CEAS first-year students and some preliminary results on student success and retention can be found elsewhere[1].

CCE 1001 is a one-credit-hour course in the design studio format in which first-year students learn and practice engineering design through instructor-guided weekly assignments. In 2010, the civil and construction engineering programs revised the Program Educational Objectives (PEO) of ABET Criterion 2[2] to include "Graduates use [their] profession to contribute to society through service to the community."[3] In response, Safe Routes to School (SRTS) became the focus of service-learning design for CCE 1001 to align with the CCE PEO.

In this paper, the improvements made in CCE 1001 as a result of implementing the SRTS service-learning design project will be described; some preliminary results of outcome assessment will be reported; and the future plan for continuous improvement will be identified.

Safe Routes to School (SRTS)

SRTS is a federal program[4] to encourage more K-8 students to walk or bike to school, thus reducing traffic congestion and pollution while also combating childhood obesity. The SRTS

initiative was started in Odense, Demark in the mid-1970's, and it is now a program of the U.S. Department of Transportation's Federal Highway Administration (FHWA) through the current federal transportation law, Moving Ahead for Progress in the 21st Century (MAP-21). The designated funding available to SRTS projects was eliminated in MAP-21, but those activities remain eligible for funding through the Transportation Alternatives program.

SRTS accomplishes its goal by improving safety and physical infrastructure and by removing barriers that currently prevent students from walking or biking to school. Schools form an SRTS action team consisting of members with expertise in transportation, engineering, education, public health, and public safety. The SRTS planning process includes education, encouragement, engineering, enforcement, and evaluation (5 E's).

The community partners for the SRTS service-learning design project are the Michigan Department of Transportation (MDOT) and K-8 schools.

Learning through Service

Learning through Service (LTS) has found currency as a pedagogy among engineering educators to help students develop the "soft" skills of teamwork and communication as well as awareness of societal impact of engineering solutions. There are many forms of LTS programs[5]: Purdue's University's Engineering Projects in Community Service (EPICS) is a multi-year and multi-disciplinary service-learning programs that are vertically integrated; service-learning is embedded into the entire engineering program at the University of Massachusetts-Lowell and Worchester Polytechnic Institute; the D80 Center at Michigan Technological University is a community-inspired research-and-design project; co-curricular or extracurricular group design projects found at many engineering schools are sponsored by organizations such as Engineers without Borders; and stand-alone courses include "Engineering Strategies and Practice" at University of Toronto, "Global Engineering Outreach Projects" at Brigham Young University, and "Introduction to Engineering Design" of this paper.

LTS has been driven by a paradigm shift in engineering education beginning with the 1994 Report of the Engineering Deans' Council and the Corporate Roundtable of the ASEE (the Green Report[6]) and cumulating in *The Engineer of 2020* by the National Academy of Engineering[7]. The incorporation of professional skills into the undergraduate engineering curriculum is made formalized by the ABET. Criterion 3, Student Outcomes, requires engineering programs to demonstrate their graduates achieve competency in teamwork, communication, and understanding the impact of technology on society and the environment[2].

An underpinning of LTS is service-learning, which is "a form of experiential learning in which students engage in activities that address human and community needs together with structured opportunities intentionally designed to promote student learning and development"[8]. *Projects That Matter: Concepts and Models for Service-Learning in Engineering*[9] is part of a monograph series on Service-Learning in the Disciplines published by the American Association for Higher Education (AAHE). Another excellent resource for teaching service-learning in engineering is a textbook first published in 2006, *Service-Learning: Engineering in Your Community*[10].

Implementing SRTS into CCE 1001

In Summer 2010, the transportation planner of the Kalamazoo office of the Michigan Department of Transportation (MDOT) collaborated with the CCE 1001 faculty coordinator to revise some of the weekly design assignments to (1) research SRTS background; (2) identify the design specifications; (3) conduct school property and neighborhood audits; (4) brainstorm solutions that take advantage of the positive factors and address the barriers to students' walking or biking to school; (5) evaluate the solutions against the SRTS specifications; and (6) create and present an action plan to the K-12 school partner.

WMU's Service-Learning Center assisted the course coordinator to identify the school partner for SRTS prior to the start of the semester. The MDOT partner worked with the school to form an Action Team, and provided detailed maps of the neighborhood surround the partnering school. Working with the CCE 1001 course coordinator, he divided the neighborhood into five zones plus the school property to allow six student teams to each work on one specific area of the SRTS design project. The student teams are assigned by the instructor based on the class schedules of the students.

In the SRTS research assignment, students research the goal of SRTS, the composition of the action team, and the 5 E's. Students are also provided with the instructions to use U.S. Census data to research about the community surrounding the school, including the population distribution by gender, ethnicity, age, educational levels, median household income, percent of population in neighborhood below poverty level, etc.

In class discussion, the student teams review the SRTS design specifications for neighborhood audit and school assessment prior to conducting an audit. The specifications for neighborhood audit identify what to look for in sidewalks or trails, street crossings, speed limit, signage for school zone and speed limit, as well as other barriers to students walking or biking to school such as abandoned cars or buildings, driver's sightline for small children, loose dogs, area of known (or suspected) crime, and whether city ordinances such as sidewalk upkeep are being followed. The design specifications for school assessment include how K-8 students exit and enter private cars or school bus at the school property and whether they are protected from other vehicles; how sidewalks, driveways and pathways on school property are maintained; how traffic flows during the start and end of school day; how well lit is the school property, and whether there are bicycle-parking facilities on school ground, their location and security, and if there are sufficient spaces.

Armed with a checklist of SRTS design specifications, students conduct field observations during a class period in an area assigned to each design team. Students are tasked to note the positive factors that support students walking or biking to school as well as the barriers. They are required to take pictures of these features for documentation and reporting. Students then make an oral progress report of their field findings.

In subsequent assignments, student teams brainstormed solution ideas that support students walking or biking to school and address the barriers, including a route for students to follow in the area of the neighborhood assigned to the student design team. Though focused primarily on

Engineering and Enforcement, many student teams proposed solution ideas in Education and Encouragement of the 5 E's. Following feedback from the instructor and the MDOT planner, students revise their ideas, evaluate them against the specifications, and make a second oral progress report on a draft action plan, using the SRTS template. Student teams also consulted with each other so that the recommended routes for SRTS for different areas of the school neighborhood are coordinated. After the draft action Plan has been critiqued by the instructor and the MDOT planner, students prepare the final action plan and design project final presentation and report.

Following the first implementation of SRTS in CCE 1001 in fall semester 2010, several improvements were made in the 2011 implementation. These included reading materials and a guest lecturer on the causes of poverty; a guest presentation from a senior MDOT engineer on the use of MDOT design standards, a public presentation to school and city officials at the conclusion of the semester; and revision of CCE 1002, "Introduction to Engineering Analysis," which is taught in the spring semester to include proposal writing to seek SRTS funding.

Preliminary Results of Student Learning Outcomes Assessment

One of the student learning outcomes formally assessed is oral communication skills. In addition to course materials on oral communication, students are provided with a rubric that will be used to evaluate their performance. The rubric assesses student performance in three broad categories: Introduction, Content, and Presentation Structure and Professionalism, and it is based on a 6-point scale from Weak (1) to Strong (6). The rubric is developed by a team of WMU researchers and it is available online (WeBAL[11]) for sharing with other engineering educators.

In CCE 1001, student teams make a total of three oral presentations, including the design project final presentation for grading but excluding the public presentation to school and city officials in which only a subset of the CCE 1001 students participated. Student performance at the first oral presentation is captured on video, and the student teams are provided with a CD of their performance as well as the critiques of the instructor and fellow students using the rubric to evaluate their presentation. In a subsequent assignment, students view the CD and critique their first oral presentation, and they are tasked to identify at least three areas for improvement. Students have reported to the instructor that they found the CD useful in improving their oral presentation skills.

Table 1 below shows the average ratings of student performance and the change from the first oral presentation to the final design project presentation for the 2010 and 2011 offerings of CCE 1001:

Table 1. Ratings of Student Performance in Oral Presentation and Change

Item Assessed	2010			2011		
	1st	Final	Change	1st	Final	Change

Team members appropriately introduced themselves or each other at start	5.17	6.00	+0.83	4.33	6.00	+1.67
The project title, topic, and objectives were clearly identified	4.67	5.33	+0.66	3.17	4.83	**+1.66**
A clear outline of the presentation was provided	2.83	6.00	**+3.17**	1.00	6.00	+5.00
Sufficient background information was provided	3.33	6.00	+2.67	1.00	5.67	**+4.67**
Findings are related to the topics of the paper	5.00	5.83	+0.83	5.00	5.83	**+1.83**
Findings seemed supported by facts or examples	3.00	5.67	**+2.67**	5.00	5.17	+0.17
Conclusions and recommendations were clear and drawn from findings	2.50	5.67	**+3.67**	3.33	5.17	**+1.84**
Visuals were clear, attractive, supportive, and handled well	4.50	5.00	+0.50	4.17	5.17	**+1.00**
Information was presented in a logical and well-organized manner	4.00	5.67	**+1.57**	5.00	5.50	+0.50
The level of information was appropriate for the audience	5.00	5.67	**+0.67**	5.00	5.50	+0.50
Transitions and rapport between team members were strong	4.17	5.67	**+1.50**	3.33	5.33	**+2.00**
The team and presentation demonstrated professional behavior and quality	3.17	5.67	**+2.50**	3.50	5.17	**1.67**

A paired t-test was conducted to determine if the improvement in performance between the first and final oral presentations was statistically significant, with α set at </= 0.05, using the software Manitab. Based on the statistical test, we determined that for 2010, student teams have made statistically-significant improvement in the following attributes of their oral presentation (highlighted in bold in Table 1): providing a clear outline of their presentation; supporting their findings with facts or examples; made clear conclusions and recommendations that were drawn from findings; presented information that was logical and well organized; presented information at a level that was appropriate for the audience; during the team presentation, the transition and rapport between team members were strong; and the team demonstrated professional behavior and quality. For 2011, the student teams have made statistically-significant improvement in the following attributes of their oral presentation: identify the presentation title, topic and objective clearly in their PowerPoint title slide; provided sufficient background information of the design project; reported findings that are related to SRTS; made clear conclusions and recommendations that were drawn from findings; presentation visual were clear, attractive, supportive and handled well; during the team presentation, the transition and rapport between team members were strong; and the team demonstrated professional behavior and quality.

Another outcome formally assessed is student awareness of factors contributing to urban poverty in fall semester 2011. Students were assigned to read two chapters on urban poverty recommended by the guest speaker and drawn respectively from the books, *Whatever it Takes* by Paul Tough[12] and *More Than Just Race* by William Wilson[13]. The guest speaker is a professor of the institution's School of Social Work. Before the guest speaker, students are asked to diagram the factors contributing to urban poverty, with the factors totaling 100%. Students are asked to diagram the factors contributing to urban poverty after the guest presentation[14].

The factors cited by the students are analyzed textually and placed into two broad categories: personal/cultural and external/environmental. The personal/cultural factors include personal attributes (attitude; lack of motivation; lazy; kids too early, drugs, bad habits) and cultural background (poor or lack of parental involvement; family instability). External/environmental factors are external to the person in poverty and include lack of employment opportunity, low wages, distance to jobs or lack of transportation, local laws and regulations, a bad economy, access to adequate health care and education, lack of government support programs, natural disasters or injury, and racism/discrimination.

Students reported an average of 1.4 personal/cultural factors and 3.3 external/environmental factors as causes to poverty prior to the guest presentation, and 1.3 personal/cultural factors and 3.6 external/environmental factors after the guest presentation.

Most commonly cited personal/cultural factor is "lack of education," cited by 65% of the 26 students in fall 2011, and the most commonly cited external/environmental factor is "lack of opportunity" also by 65% of the students.

Three students identified personal behavior ("lazy people who don't want to work," "kids too early," and "lack of ambition") before the guest presentation, and only one student identified personal behavior ("free loaders") after the guest presentation. Before the guest presentation, five students identified "racism" or discrimination" as factors contributing to poverty, while 18 students identified "racism" or discrimination" as factors after the guest presentation.

Since students complete the SRTS service-learning design project as a series of instructor-guided assignments, no formal assessment of the engineering design process was conducted.

Impact to Community Partners

Some of the recommendations from the action plan submitted by the CCE 1001 students have already been implemented by the school or city to improve safety and physical infrastructure to encourage more children to walk or bike to school. These included, for School #1, relocation of the crossing guard and installation of a new speed zone around the school. Furthermore, the SRTS Action Plan will be considered in the site design of a new school building. For School #2, the school and city are considering the proposed revision to the parking lot and parking restriction adjacent to school. These recommendations are intended to improve safety during the unloading and pick-up periods of school children.

For the Michigan Department of Transportation, the CCE 1001 service-learning design project supports this community partner's long-range transportation plan and policy objectives by providing detailed analyses of school sites for potential SRTS projects, and it keeps MDOT out front on SRTS at the federal level. Finally, the CCE 1001 service-learning design project gives this community partner the opportunity to contribute to the development of future civil and construction engineers by working on MDOT projects to start their academic career and by gaining hands-on experience with multimodal transportation. The outcome will be engineers who would be more aware of the issues of accessibility, sustainability, and livability in engineering design, and who would be more comfortable interacting with a variety of socioeconomic groups.

Sustainability of the Curriculum Improvement

A key to improving the engineering curriculum is to sustain its effort such that the improvement does not disappear due to a lack of institutional commitment or resources, or when the faculty who championed the change is no longer available to teach the course[15, 16].

Institutional commitment to CCE 1001 is demonstrated by the fact that the curriculum improvement is aligned with the program's Program Education Objectives (PEO) of ABET Criterion 2. Another evidence of institutional commitment was the recent revision of the college's strategic plan in which sustaining the STEP effort is a part of the goals for undergraduate education, and CCE 1001 serves as the anchor class for the CCE STEP cohort.

The only cost to sustain the SRTS service-learning design project is transporting the CCE students to the school site to conduct neighborhood and school property audit. In the past, this cost is covered by a course fee. Recently, the board of trustees approved differential tuition for engineering and applied sciences in which all cost fees will be removed. The transportation costs of SRTS will be supported by the revenues generated by differential tuition.

Besides providing the maps of the school neighborhood for the SRTS design project, MDOT has also donated to the CCE program hard hats and construction vests for the CCE 1001 students to wear during the neighborhood and school property audit.

Further evidence of sustainability is demonstrated in fall semester 2012. CCE 1001 with SRTS as the service-learning design project was offered even though the faculty coordinator was no longer the course instructor; he was involved in supervising two part-time instructors. The MDOT transportation planner has now joined the CCE department to teach a section of CCE 1001 to expand the number of SRTS school partners.

Conclusion and Future Work

Based on assessment of oral presentation, students have improved their oral communication skills at the conclusion of the SRTS design project. The improvements have included the following attributes of oral presentation for both the 2010 and 2011 student teams: made clear conclusions and recommendations that were drawn from findings; during the team presentation, the transition and rapport between team members were strong; and the team demonstrated professional behavior and quality.

From the reading materials, students gain awareness of the factors contributing to poverty by recognizing the personal/cultural as well as the external/environmental factors. In fact, one can assume students recognize that the external/environmental factors have a greater affect on poverty than the personal/cultural factors since students have identified more external/environmental factors than personal/cultural factors. The guest presentation has the result that students became more aware of the role racism or discrimination as a factor contributing to poverty.

Future improvements in CCE 1001 include a more effective strategy of teaching MDOT design standards so first-year CCE students can incorporate the standards into their recommendations; and a formal assessment of SRTS proposal writing in CCE 1002, Introduction to Engineering Analysis, in spring semester.

In conclusion, the SRTS service-learning design project has achieved the student learning outcomes of improving oral communication skills and gaining awareness of factors contributing to poverty. SRTS has served as a driving force to align CCE 1001 to meet the Program Education Objectives of the CCE program and to continuously improve the course content.

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