Paper ID #20133

Service Learning in Biological and Agricultural Engineering: Journeys in Community Engagement

Dr. Marybeth Lima P.E., Louisiana State University

Marybeth is a Professor in Biological & Agricultural Engineering and Director of the LSU Center for Community Engagement, Learning and Leadership. She co-authored the textbook Service-Learning: Engineering in Your Community (Oxford University Press) with Bill Oakes and is the author of Building Playgrounds Engaging Communities: Creating Safe and Happy Places for Children (LSU Press).

Dr. Ann D. Christy P.E., Ohio State University

Ann D. Christy, PE, is a professor of Food, Agricultural, and Biological Engineering and a professor of Engineering Education at the Ohio State University (OSU). She earned both her B.S. in agricultural engineering and M.S. in biomedical engineering at OSU, and her Ph.D. in environmental engineering at Clemson University. She worked for an engineering consulting firm before entering academia and continues to collaborate with the consulting industry. She has taught courses in bioenergy, biological engineering, capstone design, HVAC, thermodynamics, waste management, professional development, and engineering teaching. Her research interests include energy, the environment, and engineering education. She is assistant dean for teaching and learning in the College of Engineering. She is a second-generation woman engineer.

Service learning in biological and agricultural engineering: Journeys in community engagement

Service learning has a long history in biological and agricultural engineering involving academic student learning outcomes attainment that occurs through hands-on projects implemented in and for the community. Best practices in engagement between an academic institution and the community are characterized by mutually beneficial relationships, clear inclusion of the community partner's voice, intentional reflection by the students on their experiences, and a longer length of commitment. Service learning is built upon a foundational educational theory of constructivism where students make practical connections between what they have learned in their engineering classrooms, what they have experienced in the past, and the service project itself. In addition, it enhances student motivation because students feel that they are making a positive difference in the world beyond their engineering studies (Lima and Oakes, 2013).

This paper reviews the co-authors experiences with service learning including designing and building playgrounds for elementary schools (the 33rd was built during ASEE's 2016 conference), technical consulting service to a neighborhood impacted by local hazardous waste sites, a rooftop rainwater harvesting system for low income government-supplied housing, greywater treatment and irrigation system for a community garden, a tower garden, and a better way to make earthen bricks for rural home building in rural South African villages. Assessment measures included student portfolios, interviews with students and community clients, self-assessments by students, student evaluations of instruction, and technical quality of the final projects.

Brief descriptions of the design projects

The design projects detailed in the paragraphs below differ in approach. Lima's service-learning course has been taught in a first-year design course and has focused on a single design artifact for 19 years: public elementary school students and college students co-design playgrounds that are then built at those schools. The overall goal is to create satisfactory play spaces at all public elementary schools in Baton Rouge, LA. Christy's service-learning courses are complex, discrete, and have been completed in local and international communities. The different approaches detailed in this paper are intended to provide readers with an appreciation for the different ways in which service-learning and community engagement can be practiced within our discipline of biological and agricultural engineering.

First-year design course: Playground Design. The learning objectives of Biological Engineering (BE) 1252: Biology in Engineering, are to learn about biological engineering problem solving and design, to develop communication, teamwork, and creativity skills, and to complete a set of exercises that will enable the student to choose whether biological engineering is an appropriate major for their career goals. These objectives are accomplished by having the students work in teams to design a playground at a local public elementary school. Through this process, college students must learn about play from the true experts at play: the children; they must also facilitate the children's vision and ideas on how to best transform their playground (Lima, 2013).

Service-learning was deliberately chosen by the instructor because she wanted the students' first design experience to be an engaged one; engineers are supposed to hold the safety of the public paramount, but engineering students do not typically consider the public experts in their own right. The service-learning approach is intended to develop "humility" from the start of an engineering student's career (ultimately, Lima wants an engineer to think of him/herself as a facilitator, not "the DESIGNER"). Playgrounds were also deliberately chosen because the engineering standards that drive the engineering design process for playgrounds are not complicated, and because playgrounds are something that every student has experience with (it is difficult to design something that you know little to nothing about).

Over the course of a semester, students first learn about playground design, playground safety standards, and engineering design; they are placed into groups and they visit the school as a class twice, first to tour the current playground, meet the school administration and the children, and find out what each cohort wants to see in a playground, and at the end of the semester, for each group to present their design concept via poster for feedback from the school. Throughout the semester, each college student also serves as a reading or math tutor to a child at the school—this interaction facilitates a two-way exchange. The elementary school student learns more about math or reading, and the college student learns more about the child, their world of play, and the school community. In this way, the service-learning model used in this course is a combination placement – deliverable-based model. The placement portion (the tutoring) facilitates a better understanding of the "soul of the community" and enables the co-creation of a playground design that is a true reflection of the community it serves. The deliverable part of the service-learning project, the playground design, is the typical product of engineering service-learning partnerships.

Although the course ends with the delivery of playground designs to the elementary school, the project itself does not end until the playground is actually built. A hired group of students who are veterans of BE 1252 facilitate this process. The LSU Community Playground Project (CPP) Research and Design Team works with the school to consolidate the multiple design concepts into a single, agreed-upon design. Elementary School students vote on the aspects of which design they like most (from analysis of the posters, which hang at the school for up to one year after the collaboration is completed). College student team members use elementary school student votes, input from school administration, and detailed playground design reports completed by each group to create the first draft of a consolidated design. This design is finalized by an iterative process until the school community is happy with the design. The LSU CPP Research and Design Team then works with the school to write grant proposals and fundraise to obtain the funds to build the playground. Then, the playground is built by volunteers, which saves construction costs and builds community spirit.

Junior / Senior Biological Engineering Course: Environmental consulting experience. Students from a biological engineering course at Ohio State University participated in a site investigation at an abandoned Superfund site, the Industrial Excess Landfill (IEL) in Uniontown, Ohio. The students met with elected representatives of the affected township and engaged in a real-world environmental consulting experience. The student team projects included landfill bioreactor designs, air pollution assessment, phytoremediation designs, and critically analysis of site documents. Students traveled to the site by bus, developed and executed an environmental sampling plan, and met with township trustees and the local media. They were provided with base documents including government agency references, and other materials used by local environmental consultants. The results were a series of design reports which were delivered to the township (Christy et al., 2000).

Senior capstone design course: International humanitarian engineering design projects. At the Ohio State University (OSU), the Department of Food, Agricultural and Biological Engineering expanded the senior capstone design experience to begin at the junior year and to include the option of international design projects. For three weeks during the summer between their junior and senior years, teams of students would travel to South Africa to meet with community groups and define design needs. The student teams then returned to the US and worked on year-long capstone design projects relating to an issue they had identified in South Africa. After completing their capstone, several students then returned to Africa with the next year's cohort to assist with implementation of their design concepts (Ward et al., 2007; Christy et al., 2008).

Rooftop Rainwater Harvesting System: In South Africa, millions of people live in poverty and reside in informal settlements or shantytowns. Dwellings in these settlements do not meet basic health and safety needs and often lack fresh water, sanitation, or electricity. To address this issue, the Reconstruction and Development Programme was established in to provide housing for its impoverished citizens. Many of these houses have corrugated metal roofs with no gutters. Soil erosion, flooding, and water borne diseases are problems in these new housing communities. Water is scarce and most residents quickly use their small free monthly water supply allotment. capstone students working on this project designed and built systems of gutters, rain barrels, and simple valved piping networks to be used to flush toilets,

Community Garden Irrigation System: Capstone students working on this project met with elementary school teachers and community members at the Muzi Thusi Elementary School near Pietermaritzburg. Students designed and built a natural filter for treat grey water generated at the school and then piped the treated water into a drip irrigation system designed for the school's community garden. The goal of the design was to reduce the school's dependency on expensive municipal water.

Tower Garden: This student team had been inspired by the South African subsistence farmers' tower gardens they had seen at a rural Potshini village during the previous summer and determined to improve that design by modifying the internal water distribution system. The cylindrical-shaped units held together with burlap and filled with soil and crushed rock were able to grow vegetables (tomatoes and basil) in a limited space while also conserving water. The following year, tower gardens were constructed at two locations in KwaZulu-Natal.

Earthen Bricks for Rural Home Building: These students tested different mixtures of medium sand, vermiculite, pea gravel, and Portland cement in constructing bricks for use in building rural earthen block housing. Hand tampered cores were dried, cured, and tested for compressive strength. Thermal tests were also conducted on the cores. The students also developed a design for mechanically compressing earth blocks, an improvement over the hand tamping process used by the rural South African community.

How the service learning projects integrated into the curriculum

LSU. The first-year course BE 1252 is one of two courses in the core curriculum that involves service-learning. A junior level service-learning course in biomaterials requires students to work with a middle or high school teacher to develop a grade-appropriate interactive lesson on an engineering property. Students work in groups to create an interactive lesson, with formative assessment from the K-12 teacher and college instructor. They execute the lesson twice and reflect on the process. The instructor of the junior level course builds on the service-learning basics in BE 1252.

Although service-learning was added to both courses at the initiation of the faculty member teaching them, the entire department is supportive of the service-learning approach because of the ease of assessing student learning outcomes (SLO) in ABET that may be more difficult to assess without such an approach, including h. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context, and i. a recognition of the need for, and an ability to engage in lifelong learning. Because all faculty members participate in SLO assessment for ABET, all are supportive of service-learning.

A third service-learning core course is now being planned and will be taught for the first time in Fall 2017: BE 1251, the first core BE course, will be taught using this pedagogy. The course is being linked with BE 1252. In BE 1251, students learn to draw using AutoCAD and Inventor; using the new approach, college students will work as math tutors at local public elementary schools. They will also work in groups to create math manipulatives (interactive, fun math games to assist elementary school students with learning math)—college students will build or fabricate (in shop or with 3-D printing) a game, which will become the property of the elementary school. BE 1251 and 1252 will be linked because the students enrolled in these courses will work with the same elementary school for the entire year, and will serve as math tutors at the school for an entire year, while producing two deliverables: a math manipulative, and a playground design.

This approach also fits more broadly into an Engaged Citizens program that LSU is in the process of launching; to earn this distinction upon graduation, a student must complete at least 7 credit hours of service-learning courses, complete 100 hours of community service (additional to the service hours completed through service-learning courses), and must write a brief paper describing the ways in which their experiences helped them to meet LSU's Commitment to Community (https://www.lsu.edu/hrm/pdfs/LSU_Commitment_to_Community_item72411.pdf). The concerted effort of the BE faculty to offer seven credits of service-learning courses in the core curriculum means that students are placed in an advantageous position to earn the Engaged Citizen graduation distinction.

OSU. The international (South African) projects contributed to both the required and elective B.S. curriculum. The study abroad course could be counted toward participating students' technical electives, while the capstone design course sequence fulfilled a curricular requirement. The Ohio State University also has several other ways for student to earn credit for engaging in engineering design for community service: the Global Option in Engineering <https://engineering.osu.edu/students/undergraduate-students/global-option-engineering> and the Humanitarian Engineering minor < https://osuhe.engineering.osu.edu>.

In order to earn the Engineering Global Option designation, OSU students must complete coursework and/or fieldwork in each of the following four categories:

A. Early Education Abroad (3 credit hours)
B. International Elements of Engineering (3 credit hours)
   Courses involving international elements that apply engineering/technical knowledge
   OR
   Co-op/Internship outside the U.S.
C. Foreign Culture or Language (6 credit hours)
D. International Engineering Design (6 credit hours)

In 2015, a biological engineering student was the first student to graduate from OSU with the Global Option in Engineering distinction. Her capstone design team had designed a more efficient cookstove to help families in rural Nicaragua cook using less firewood and with effective ventilation.

The Humanitarian Engineering Minor is a program co-coordinated between four OSU departments:

- Food, Agricultural, and Biological Engineering
- Engineering Education
- Electrical and Computer Engineering
- Civil, Environmental, and Geodetic Engineering

To complete the minor, students take a core Humanitarian Engineering course (3 credit hours), two courses on human welfare (6 credit hours, typically double counting with general education courses), and design project / service learning courses (6 credit hours).

Assessment techniques

Assessment is done using typical methods. For example, final playground design reports and posters are assessed by rubric. The students are given these rubrics and are encouraged to self-grade their reports and posters using the rubric before they turn in the drafts for feedback. Student reflections are also graded by rubric, with examples (poor, satisfactory, excellent) provided for guidance.

The service-learning component of the LSU first year course involves assessment that is non-typical as well. Playground designs are assessed by elementary school students and administration—admittedly, college students work hard on their posters (which are checked carefully by instructor and usually go through several iterations before they are released for printing) because they are afraid of being “booed” by elementary school students. Although the tutoring success of college students is not assessed individually, the tutoring model is administered by a non-profit organization; this group measures test scores of all elementary school participants, and has shown that students who participate in the tutoring program close achievement gaps of a half year on average. For example, if a child is a year behind grade level in reading, at the end of a school year while participating in the tutoring program, the child is now a half a year behind in grade level.

Finally, in terms of accreditation, our faculty developed several performance indicators (PIs) to assess SLO h, the broad education necessary to understand the impact of engineering solutions in a global and societal context. One of these PIs is the student understands the significance of context for an engineering solution. The final report for BE 1252 is one artifact used to assess this PI. For SLO i, a recognition of the need for, and an ability to engage in lifelong learning, one of our PIs is: students demonstrate that they are reflective practitioners (understand principles of reflection and demonstrate those principles). We use the final reports for BE 1252 and for the junior level biomaterials class to assess this PI.

At OSU, onsite project assessment is considered to be key to a successful project outcome (Bixler et al., 2014). Onsite assessments, performed in close collaboration with the partner community, allow the design proposal and actual work to be performed in a way that is mutually agreeable among all stakeholders. Group assessments, using quantitative and qualitative measures, are defined at the start of each project and continue throughout the project including post implementation (Passino, 2016).

Future directions

Lima has been focused on working with individual public schools and the school system to ensure that all have satisfactory playgrounds. After a 19-year effort, the “end” is in sight—although playgrounds will always need to be upgraded at the end of their useful lives, within several years, the goal will have been met. The playground project will continue (in addition to routine upgrades, there are 10 surrounding parishes (counties) and no shortage of interest), but Lima anticipates different service-learning projects in the future. One possibility would be designing and building outdoor relaxation spaces for public school teachers; such spaces have been requested numerous times by teachers employed by collaborating schools. Teachers seem to need “a room of their own,” as well as public support—the average career length of a public school teacher is 5 years. Lima is also interested in the ways that enrollment in service-learning courses impacts the volunteerism habits of engineering students before and after graduation.

At the Ohio State University, Christy was part of a university-wide initiative to develop a comprehensive blueprint for Ohio State’s service-learning programs. Specifically, the committee focused on:

- Defining student developmental outcomes
- Identifying many diverse existing pathways (curricular and co-curricular) to achieve these outcomes

- Identifying obstacles or other limiting factors to student, faculty, and community partner participation in service-learning programs

Some of the proposed curricular changes include encouraging more departments to include service learning components within their courses and curricula, and also modifying the common general education requirements to allow students to work through questions related to privilege, social justice, and community engagement. BAE faculty will continue to be deeply involved in this ongoing work.

References

Bixler, Greg, Joseph Campbell, Roger Dzwonczyk, Howard Greene, John Merrill, and Kevin M. Passno, 2014. Humanitarian Engineering at The Ohio State University: Lessons Learned in Enriching Education While Helping People, *International Journal for Service Learning in Engineering*, Special Edition, pp. 78–96, Fall 2014.

Christy, Ann, Andy Ward, Jeff Hughes, Simon Lorentz, and Bethany Corcoran. 2008. An Experiential and Service Learning Capstone design Initiative in South Africa. *2008 ASEE Global Colloquium,* American Society for Engineering Education. CapeTown, South Africa, October 2008. Paper # GC 2008-124. 11 p.

Christy, Ann D., Julie Weatherington-Rice, and Andy D. Ward. 2000. Use of a Superfund site as a hands-on learning laboratory for engineering design students. *Ohio Journal of Science* 100(1): A-27.

Lima, M. 2013. *Building Playgrounds, Engaging Communities: Creating Safe and Happy Places for Children.* Baton Rouge, LA: LSU Press.216 p.

Lima, M., and W. Oakes. 2013. *Service-Learning: Engineering in Your Community*. 2nd ed. Oxford University Press. 336p.

Passino, Kevin M. 2016. *Humanitarian Engineering: Advancing Technology for Sustainable Development.* 3rd edition, Bede Publishing, Columbus, Ohio, 785 pages <https://hebook.engineering.osu.edu >

Ward, Andy D., Kerry Hughes Zwierschke, Carol Moody, and Ann D. Christy. 2007. Developing Sustainable Solutions for Impoverished Communities in South Africa: A Student Centered and Service Learning Capstone Design Experience." *American Society of Agricultural and Biological Engineers Annual Meeting.* ASABE Paper 07-8018. 8 p.