A Capstone Course Integrating Student Leadership Development and Community-Based Service Learning

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The Paul Peck Scholars Program in Drexel University’s College of Engineering provides a curriculum framework that helps develop students’ skills in leadership, management, communication and mentorship. The capstone course of this three-year sequence is an engineering service-learning project, where students must address the needs of a community partner by dovetailing their engineering coursework and internship backgrounds with the skills gained through the Peck Scholars program, in the model of an EPICS (Engineering Projects in Community Service) class. In this paper, we present the academic sequence and structure of the Peck Scholars Program, intended goals and learning outcomes of the program, and challenges faced during project implementation. We also present a recent project developed in a capstone course, an automatic water delivery system for vegetable plots at an urban school.

I. Introduction

The Paul Peck Scholars (PPS) program1 is an application based leadership development program for undergraduate engineering students. Through this program, students learn that the essence of leadership and innovation lies in the ability to communicate effectively, apply critical thinking and reasoned problem solving to any situation to produce tangible and measurable results. This is achieved through special courses, integration of curriculum, seminars, and specialized co-op opportunities that are directed at developing the next generation of technological leaders.

Engineering Projects in Community Service2 (EPICS) at Drexel3 is a program that aims to provide students with professional skills and volunteer opportunities, provide faculty with a bridge to link their academic expertise with civic engagement, support community building between the University and local non-profit community organizations, and provide community partners with support on STEM initiatives. This program, lasting anywhere between 10 weeks and 9 months, is designed for College of Engineering undergraduate students to focus on technical design challenges and related projects with local non-profit community organizations such as museums, community centers, and environmental centers. EPICS projects consist of engineering students of multiple disciplines and are supported by a faculty advisor. Key successes of this program at Drexel are that students appreciate the opportunity to obtain real world experience as they work to translate their academic knowledge into a more practical application. Secondly, community organizations have articulated technical needs that can be researched or prototyped with significantly less cost by students compared to professionals.

II. Review of academic program

Since its inception in 2009, the Peck Scholars Program has grown to a multi-year program that has the primary focus of leadership development. In its initial design the program was a mentorship program where upperclass students mentored a group of first-year UNIV 101 students, similar to the role of a teaching assistant. The program later changed to focus more on

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small group mentorship while also providing the upperclass mentors the opportunity to gain additional skills.

The course sequence begins with sophomore or pre-junior (3rd year students) who develop leadership skills through mentorship pairings with freshman students. While mentors participate in small groups with their freshman mentees, they are simultaneously enrolled in a 1 credit mentorship course. They then take a leadership course the following term. Following this experience in the first year, students continue to take classes in organizational behavior, engineering management, an elective of their choice (such as technical communication, or engineering education) and finish the program with a final capstone course.

In addition to the required coursework and out of class mentoring experience, students are also required to complete 12 hours of community service per year as a way to be a more proactive citizen in Philadelphia and grow their network outside of the University. Finally, as part of this program, students are also provided the opportunity to attend conferences and limited funding is available for students who want to pursue unpaid research opportunities or international internships.

In the 2015-2016 academic year the program touches approximately 125 students. Of that, about 75 students are named Peck Scholars. About 30 of those students serve as direct mentors to 50 first year engineers. Since 2012, when data collection began, students who are named Peck Scholars show a 100% retention rate at Drexel University and a GPA higher than non participants. Program participants show higher retention rates and GPAs than non-participants, which is likely due to the mix of peer mentorship, skills development, and a network of students who are driven to be active in their community.

III. Capstone course pilot, 2013-14

At the request of students to enhance the Paul Peck Scholars program sequence and in response to a perceived need from the program coordinators, a final capstone course was first implemented in the 2013-2014 academic year. The capstone class aims to combine skills such as problem solving, verbal communication, team work, writing, and service into one final class that requires students to work one on one with a community partner, the ‘stakeholder,’ on a multidisciplinary engineering design problem. This relies on leadership, initiative, time management, and independent thinking to help students strengthen their engineering knowledge through a practical application and become more engaged as active citizens in their community.

When initially designing this capstone class, the PPS program administrators were familiar with the EPICS model and were seeking to implement a course sequence as well as more hands-on learning among engineering students. The students in the capstone class proved to be a good pilot group for this project. In the pilot class, 6 students built a lightweight portable lawn chair for a historical botanical garden just 2.5 miles (4.0 km) from campus. Student feedback from this initial implementation was constructive. Students appreciated the goal of the project and the community partner was pleased with the physical deliverable and had no trouble working with the students. However, students felt that more technical advising and a longer amount of time to
work on the project would have enhanced their experience and the benefits of the class and project.

IV. Development of the current capstone course

The sustainability program manager for the Philadelphia School District’s Office of Environmental Management Services (OEMS) was referred to the Paul Peck Scholars program coordinator by Green City Teachers, an initiative by the Pennsylvania Horticultural Society to train Philadelphia teachers on how to start gardens at their schools and incorporate gardening into curriculum. OEMS saw the potential for alignment between the goals of the Peck Scholars program and the school district’s sustainability plan, which has the following focus areas: sustainability for education, consumption and waste, healthy schools, green school years, and energy and efficiencies.

In November 2015, initial collaboration began between the Peck Scholars program coordinator, Drexel University faculty and staff, and OEMS to clarify the objectives of this collaboration. OEMS wanted Peck Scholars students to design an irrigation system for one school’s garden, with the intention that the system could be easily replicated at schools throughout the district. This would require the Peck Scholars to also produce a supplementary “how-to” document that could be distributed to additional schools which would address materials, measurements, installation procedure, maintenance, and ideas on how to incorporate this system into a K-12 course curriculum. More information on this project can be found in the next section. The Science Leadership Academy at Beeber (known as SLA@Beeber), a magnet high school in the Overbrook neighborhood of Philadelphia, was identified by OEMS as the initial school district partner.

The Paul Peck Scholars Capstone course was created to provide an academic framework for the project. The course was offered as a two-credit special topics course under an Engineering rubric (ENGR 380) with 2 meeting hours per week for 10 weeks. In winter quarter, ten junior-level students enrolled from majors ranging from Materials Science & Engineering to Mechanical Engineering. While the course did not have a required textbook, a book often used in EPICS programs was used for guidance on topics such as constituent needs assessment and product design. Critical items from the course syllabus, including the course description, goals, and outcomes are in Table 1.

The course begins with an exposure to the EPICS model and how their collaboration with SLA@Beeber addresses many of the objectives of an EPICS project. Guest speakers from Drexel’s Lindy Center for Civic Engagement discussed the importance and impact of engaging with the local community and how engineering students specifically can contribute their skills to helping those around them.
Table 1. Information from the syllabus of the 2015-16 capstone course

Course Description:
This is the final course of the Paul Peck Scholars Program, which aims to improve students’ leadership, problem solving, and communications skills through mentorship, scholarship, and civic engagement. This course requires students to utilize the skills developed through their degree programs and the Peck Scholars curriculum to solve a problem in the local community. Students will then present their solution to the relevant parties at the end of the term.

Course Objectives/Goals:
- Students will be able to articulate the skills they have acquired throughout their time in the Peck Scholars program in problem statements, presentations, and papers
- Students will become socially engaged in the Philadelphia community
- The student cohort will work closely together with community partners to solve an identified problem through the lens of engineering

Winter 2015-16 Project Information:
- Through collaboration with and constraints identified by the Green City Teachers program in the School District of Philadelphia, Peck Scholars students will create a sustainable, cost effective irrigation system for one school garden

Learning Outcomes:
- Students will appropriately size and design a water delivery system for an urban garden
- Students will utilize VoiceThread and other tools to communicate shareable methods on how to construct water delivery system for replication at additional school gardens

In response to the feedback from the pilot, the course staffing was expanded to include two engineering faculty as technical advisors, Dr. Mira Olson from Civil, Architectural, and Environmental Engineering, and Dr. Kevin Scoles from Electrical and Computer Engineering. Faculty were not released from their normal teaching load, but did receive a small stipend. Through the instruction and mentorship of Dr. Olson, students learned about irrigation requirements and how to account for hydrologic processes such as evapotranspiration and infiltration when designing a system to automatically irrigate at soil moisture content levels below an established threshold for the items growing in the gardens. Dr. Scoles introduced the students to the product design process, including the important processes of identifying all constituents and their needs, and how to identify the best options given the constraints set by said constituents. He also gave an overview of irrigation hardware such as soil moisture sensors and battery-conserving latching solenoids. Students then spent several class periods brainstorming design options as a class or in sub-groups (water sourcing, control, water distribution), identifying materials, collaborating with the teachers at SLA@Beeber, and developing a proposal.

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for system installation. Constituents received the design proposal via VoiceThread®, a multimedia presentation tool that supports threaded discussions.

ENGR 380 is still in process, and, after a lengthy background check process required by Drexel University and the state of Pennsylvania, the ENGR 380 students have visited SLA@Beeber on a number of occasions to take measurements, install a prototype for testing, and educate high school sophomores and juniors on aspects of the project.

V. Details of this term’s project

The initial objectives for this project were identified by the sustainability program management at OEMS: an urban garden irrigation system that requires minimal maintenance, is cost-effective, and can be easily replicated (for this, OEMS also wanted Peck Scholars students to develop an instruction manual that could be distributed to interested parties around the school district).

OEMS and the teachers at SLA@Beeber have given the Peck Scholars students significant latitude in completing this project. While one constraint was for the project to be cost-effective, OEMS’s definition of “cost-effective” is dependent on each individual school’s resources; when presented with the combined $2000 that the Peck Scholars Program and SLA@Beeber set aside for the project, OEMS did not find that unreasonable. This trend is reflected in other areas of the project: as long as the Peck Scholars are addressing the five focus areas of OEMS’s sustainability plan (above), OEMS has let the students work fairly autonomously. Given the other commitments of the partner teachers at SLA@Beeber, opportunities for collaboration, input and constraints from SLA were minimal.

Peck Scholars have designed an irrigation system for two rows of raised-bed gardens, each row having five boxes. The system uses water from a nearby spigot that, using a hose splitter, feeds two irrigation controllers. Each controller is powered by a solar panel and back-up rechargeable AA batteries, and has a soil moisture sensor. These irrigation controllers then release the water as needed through their row of garden boxes, which are 4 ft by 8 ft (1.2 m x 2.4 m) each. Each hose has drip tubes branching every 1 ft (0.3 m) to evenly saturate the soil.

In order to protect the most expensive part of this system, the programmable irrigation controller, the Peck Scholars designed specifications for boxes that account for security, air flow, programming access, and the azimuth and elevation angles of the solar panel situated on top. On the group’s initial visit to the school they learned that SLA@Beeber has a “Maker” group, with a number of trained student-fabricators and an extensive woodworking capability. This offered an unexpected and very helpful partnering opportunity between Drexel and SLA@Beeber students. The controller box specifications were given to the SLA@Beeber Maker Lab students to create.

The irrigation system is currently being installed at SLA@Beeber. Sophomores and juniors from SLA@Beeber have received lessons from their teacher and Peck Scholars students on how the system was designed, how the automatic irrigation sensors work, and how work like solar surveys are useful in determining placement of gardens, and what sort of plants, fruits and vegetables can grow successfully in different exposures.
Peck Scholars will collaborate with SLA@Beeber students and faculty throughout the rest of the term, instructing the students on how to install the full system.

VI. Conclusions

Ehrlich\(^7\) described several directions for incorporating service-learning in undergraduate education, one being the enhancement of academic learning, and another the development of “the skills and knowledge needed for leadership.” Our original goal for this course was the second, keeping with the PPS program leadership outcomes, but in execution we may have succeeded in both. The capstone broadened the education of the students into an area in which they had no prior experience. While the project is not yet complete, the students have drawn from their experience and training in the Paul Peck Scholars program to produce an engineering solution that will meet the needs of a long list of constituents.

Through their capstone course, the Paul Peck Scholars have had an opportunity to participate in an engaged scholarship\(^8\) activity that accesses and augments their background in leadership. The PPS capstone and EPICS share the same goal of community engagement. The academic framework developed for this capstone course may be used to develop a new series of EPICS courses to bridge the design experience gap between freshman and senior years, and give engineering students the opportunity for a continuous experience in community engagement. Having the PPS students work within the continuity of an established course sequence could relieve some of the time pressure of the current capstone, and provide some additional mentoring and leadership opportunities.

We hope that our relationship with SLA@Beeber and the Philadelphia School District can continue beyond this quarter, and that we can cooperate on the development of STEM or pre-engineering materials related to the science and engineering used in gardens, water management, and autonomous irrigation systems and the environmental data that might be recorded from them, and see them integrated in K-12 curricula within the School District of Philadelphia.

VII. References

3. EPICS at Drexel, Drexel University, Available: http://www.epicsatdrexel.com
