WIP: Implementing a Community Engagement Project in a First-Year Foundations of Engineering Course

Matthew James, Virginia Polytechnic Institute and State University

Matthew James is an Associate Professor of Practice in Engineering Education at Virginia Tech, and is a registered Professional Engineer in the State of Virginia. He holds bachelors and masters degrees from Virginia Tech in Civil Engineering.

Dr. Juan David Ortega-Alvarez, Virginia Polytechnic Institute and State University / Universidad EAFIT

Juan David Ortega Álvarez is a Collegiate Assistant Professor in the Department of Engineering Education at Virginia Tech and a Visiting Professor of Engineering at Universidad EAFIT (Medellin, Colombia). Juan holds a Ph.D. in Engineering Education from Purdue University and an M.S. in Process Engineering and Energy Technology from Hochschule Bremerhaven. In addition to teaching undergraduate and graduate courses for more than 10 years, Juan has over 6 years of experience as a practicing engineer, working mostly on the design and improvement of chemical processing plants.

Cassondra Wallwey, Virginia Polytechnic Institute and State University

Cassie Wallwey, PhD is a Collegiate Assistant Professor in the Department of Engineering Education at Virginia Tech. Her research interests include studying effective feedback in engineering and mathematics courses, improving engineering student motivation and success, and understanding exclusion in engineering to fight its weed-out culture. Cassie has her Ph.D. in Engineering Education from Ohio State University, where she worked as a Graduate Research Assistant and Graduate Teaching Associate, primarily teaching first-year engineering and engineering mathematics. She also has both a B.S. and M.S. in Biomedical Engineering from Wright State, where she also worked as a Graduate Teaching Associate for an engineering mathematics course.

Dr. Michelle Soledad, Virginia Polytechnic Institute and State University

Michelle Soledad, Ph.D. is a Collegiate Assistant Professor in the Department of Engineering Education at Virginia Tech. Her research and service interests include teaching and learning experiences in fundamental engineering courses, faculty development and support initiatives – including programs for the future engineering professoriate, and leveraging institutional data to support reflective teaching practices. She has degrees in Electrical Engineering (B.S., M.Eng.) from the Ateneo de Davao University in Davao City, Philippines, where she previously held appointments as Assistant Professor and Department Chair for Electrical Engineering. She also previously served as Director for Communications and International Engagement at the Department of Engineering Education at Virginia Tech, Lecturer at the Department of Engineering Education at The Ohio State University, and Assistant Professor at the Department of Integrated Engineering at Minnesota State University, Mankato. She holds a Ph.D. in Engineering Education from Virginia Tech.

WIP: Implementing a community engagement project in a first-year foundations of engineering course

Introduction

This paper seeks to explore the benefits and challenges of incorporating community engagement projects into an existing first-year engineering course. Instructors have noted over the years that students in engineering courses often find it difficult to relate to non-technical issues, especially material that does not have a tangible product as an outcome or answer, and sometimes struggle to relate concepts that, while important, are more theoretical to their intended majors and careers [1]. In the authors' experiences, foundational engineering courses that cover non-technical skills such as problem solving, teamwork, communication, recognition of holistic issues, and other important transferable skills are especially prone to this challenge of engaging students who come into the discipline expecting engineering to look more like the more concrete math or science courses they are familiar with from their prior studies. Community engagement projects, also commonly referred to as service-learning projects, are one way that instructors facing similar challenges have succeeded in engaging students within courses such as these [2].

The course in which the study is situated is a foundational first-year engineering course required of all students entering the engineering program at a large land-grant institution in the Southeast United States. Students typically take a two-semester sequence of general engineering courses before declaring a major and moving into their degree-granting departments. The first-semester course focuses on engineering problem solving skills, holistic issues, introductory programming in MATLAB, communication, and teamwork; the second semester course builds on this and further introduces students to the engineering design process. While the program typically serves first time in college students, many transfer students (both internal to the institution and external) also are required to take the sequence of courses. It is notable that the implementation of the community engagement project in this study takes place in the "off semester" cycle, which primarily serves the nontraditional group of students rather than the "typical" first-year population.

Community-based learning, or service-learning, is a teaching strategy where students are tasked with a project that benefits a community partner through solving an authentic community problem. These kinds of projects have been shown to help students' perceptions of course material as well as their own futures in a chosen field or major, among other benefits [3], [4]. For such a project to succeed, it should be designed in a way that is mutually beneficial to the students and project partners; in other words, the subject of the project should directly relate to the learning outcomes of the course, and thus student learning, but also have a benefit to the community partners with whom students are working that reaches beyond the confines of the classroom and traditional academic learning environment. Many programs have successfully developed similar projects in their courses, including some covering introductory concepts similar in scope to ours [5], [6], [7]. However, this process is not without challenges. Developing and maintaining strong partnerships, defining mutually beneficial projects, ensuring that projects that fit within the workload expectations of the course, and balancing the workload of community partners, the instructional team, and the ability of students to connect with their

project sponsors are all factors that come into play when evaluating whether such projects are appropriate for a course.

This study focuses on describing the planning and development process of implementing community-based service-learning projects into the Foundations of Engineering course at the study institution and outlines a plan for evaluating the impact of the projects on students' perceptions of the usefulness of course material, specifically related to those learning outcomes that instructors have identified as historically difficult for students to appreciate. These projects are being piloted in three course sections of 60-67 students (approximately 190 students total) led by a single instructor in the Spring 2024 semester.

Course Development Process

The study institution's general education office provided small grants for increasing students' opportunities to take part in community engagement projects throughout the curriculum, whether through redevelopment of existing courses (such as the one described in this study), or development of new course opportunities. The Foundations of Engineering course for this study fulfills part of a general education requirement for design, and has six student learning outcomes (LO):

LO 1. Compare and contrast the contributions of different types of engineers in the development of a product, process, or system.
LO 2. Articulate holistic and ethical issues that impact engineering solutions.
LO 3. Solve problems using systematic engineering approaches and tools.
LO 4. Model an engineering system.
LO 5. Communicate solutions and arguments clearly.
LO 6. Develop teamwork skills.

At a departmental level, the intent of implementing these projects is to offer several sections each semester for students (and faculty) who have an interest in community engaged learning without needing to modify the existing learning outcomes of the course. As such, we began the process by identifying areas in which there might be alignment, or potential misalignment, between the best practices of community engagement projects and the existing student learning outcomes. The strongest alignment appears to be for LO 2, which asks students to demonstrate an understanding of the broader impact of engineering skills. The course has historically approached this LO by asking students to focus on stakeholder impacts, which we believe can be improved through having an external stakeholder in their project partner. There is also an opportunity for alignment with LO 5, which relates to communication skills. The teaching team hopes that having an external partner will motivate students to think more broadly and critically about how they communicate their information if given a project that could have a real impact outside of the classroom, a goal supported by literature showing success of service-learning in introductory engineering courses [5].

Once it was determined that working with a community partner would not require a restructuring of course learning outcomes, we looked at what kinds of adjustments would be necessary for the main project assignments throughout the semester when compared to previous offerings of the course. For purposes of this study, the assignments will be compared with a prior version of the

course in which students self-identified campus problems to explore throughout the semester. Five key assignments were identified as needing some degree of modification or adjustment to best facilitate the implementation of the new project approach (Table 1).

Table 1: Proposed Assignment Modifications

Assignment	Goals	Proposed Changes
Startup Documents (Team)	Set initial expectations for the semester project as well as provide an initial understanding of the project theme and scope.	Revised to include a section asking students to describe why they think this project is important to their project partner, as well as restating the project theme in their own words.
Problem Scoping (Individual)	Ensure that each team member has done sufficient background research into their problem topic; organizes important information found into a simple system diagram showing the relationship between components	This assignment previously asked each student to explore a different idea, and then teams would choose which they wanted to explore for the remainder of the semester. The new version has been narrowed to limit students' research into the overarching topic/project theme identified by their partner.
Problem Definition (Team)	Builds on the individual problem scoping assignment by asking the team to focus in more depth on one or more portions of the problem system and identifying important questions to be answered in the problem-solving process.	Whereas past versions would build on a single team member's idea, the revised version will focus on synthesizing information based on all team members' initial research. Additional information related to reflection on community engagement is also proposed to be added to this space. It is intended that teams will receive feedback from their project partners on this document to inform their subsequent work.
Data Exploration (Team)	Opportunity for students to explore real-world data sets, whether existing data or collected by the team. Students are tasked with identifying the data's context, limitations, and potential uses in helping better understand and solve engineering problems.	This assignment has been broadened to include situations in which the project partner provides one or more data sets to student teams to explore.
Analysis and Recommendations (Team)	This summative assignment asks student teams to synthesize the quantitative and qualitative data that they have	Depending on the project partners' needs, the final deliverables may need to be tailored to individual projects. For example, some projects may be best

	gathered throughout the semester to make recommendations for future work in solving problems related to their project.	suited to a poster session, whereas other partners may prefer a recommendation report. A poster session has been proposed for the project partners working with the students in the pilot semester.

Following this analysis, the next (and arguably most important) step was to identify project partners and begin discussions about the scope of projects, needs, and shared expectations. For the semester in which these projects would be run as a pilot (Spring 2024), we leveraged existing connections and reached out to project partners who had worked with students in other courses in the first-year program in the past, notably staff in the university's Facilities department. Several staff members had successfully worked with student teams in Spring 2023 in the design-focused first-year course and indicated enthusiasm about continuing a working relationship with the program. Although the project partners are housed in the same institution, due to the size of the campus and organizational structure, the Facilities Department and undergraduate students rarely interface with each other and are distinctly separate parts of the campus community.

Coordination with staff at Facilities was initiated mid-way through the prior semester, initially with a meeting with one staff member in an engineering director role who then met separately with others in his unit to brainstorm topics. The initial meeting covered the overall learning goals of the course, the backgrounds of the students taking it, and showcased examples of deliverables from prior course offerings to help provide context and set initial expectations for the level of technical expertise and engagement to be expected from students. A list of the initial rough project descriptions and project sponsors was sent to the course instructor to review, and a follow-up meeting was scheduled to further refine and discuss these ideas to ensure that they could be aligned with the course outcomes.

Initially, ten projects were identified by Facilities staff. Of those, three were found to be in close alignment with the course learning outcomes and planned class activities, three more were able to be used after modification and further communication between the course instructor and the project sponsor, one was found to be too technically complex for the course, and an additional two ideas were proposed through further brainstorming after the meeting. Ultimately, six project topics were selected, each to be explored by 5-6 student teams with one project partner/sponsor. Examples of the chosen projects include themes such as improving congestion due to pedestrian pick-up and drop-off, reducing campus landfill waste, and investigating the effectiveness of occupancy monitoring in campus buildings.

Proposed Evaluation of Course Impacts

As previously described, embedding community engagement projects in a traditional course is not a trivial endeavor. While it holds the potential to enhance student engagement and spark interest in a specific subject or discipline, a substantial planning and coordination effort is required to introduce authentic problems into the classroom. Moreover, some previous studies have found that sometimes the expected benefits of these kinds of projects on student motivation are marginal, at best, when evaluated throughout the course of a semester and suggest that there may be other equally influential factors to consider [8]. Therefore, we aim to evaluate the impact of integrating community engagement projects into the pilot sections to inform further decisions on expanding and sustaining this initiative.

To guide the evaluation process, we consider adopting the tenets of the Course Acceptance Model (CAM) as a suitable conceptual framework [3]. According to CAM, students' overall perception of the value of a service-learning-service-based course can be measured by evaluating four constructs: perceived ease, usefulness, attitude, and future use. Given that students of first-year foundational courses, ours included, often do not outwardly note the value in the coursework, we have chosen to evaluate students' views of the course through the lens of this framework. The constructs as they relate to the CAM propositions are reproduced below [3]:

1. Perceived ease of course material will have a direct positive effect on the perceived usefulness of course material.
2. Perceived usefulness and perceived ease of course material will have a direct positive effect on favorable attitudes towards the course.
3. Favorable attitude toward the course will have a direct positive effect on intentions to use the course material in the future.
4. Perceived usefulness of course material will have a direct positive effect on intentions to use the course material in the future.
5. Participation in service-learning projects will have a positive effect on the perceived usefulness of course material.

In this paper, we intend to evaluate whether the initial findings of the CAM apply in the context of our first-year engineering course. The learning outcomes that students often, in our experience, struggle to relate to their other coursework (i.e., holistic issues, communication, and teamwork) are well-aligned with the goals of service learning, and we hope to see whether the inclusion of these types of projects helps students better understand their importance in an engineering context. For consistency, we will refer to these as "non-technical" outcomes throughout this paper. The research question that the study team aims to answer is:

Can the implementation of community engagement projects in a problem-solving first-year engineering course improve students' perceptions of the usefulness of non-technical learning outcomes that they often find to be abstract or unrelated to their other coursework?

Methods

We intend to evaluate the effects of incorporating community engagement projects in the course by administering a survey near the end of the semester that will help us understand students'

perceptions of the four constructs found in the Course Acceptance Model (CAM). The department where this course is offered has historically administered an end of semester survey that includes a section with questions from the MUSIC Model, which records student responses using a Likert scale [9]. While the MUSIC model questions are no longer included in the departmentally administered survey, we have identified questions that appear to be in close alignment with the CAM constructs and will separately record student responses to these this semester to make a comparison with students taking versions of the course without a community engagement project. We intend to compare responses in Spring 2024 to other "off-cycle" semesters, which are more likely to have a similar group of students (i.e. transfer students, students repeating the course, taking the class as an elective, etc.) to minimize the differences that could arise from a comparison with students taking the course in the Fall (primarily first-time in college students). Approximately 190 students were enrolled in the pilot semester, with 4% of students noting they were taking the course for elective credit, 15% first-time general engineering students, 13% repeat engineering students, 51% internal transfers from non-engineering majors, and 16% identifying as transfer students from other institutions.

The following questions, based off past surveys, have been identified as good candidates to achieve this goal, and are organized according to the four constructs of the CAM:

Ease

- I was confident that I could succeed in the coursework.
- I felt that I could be successful in meeting the academic challenges in this semester.
- I was capable of getting a high grade in the course.
- Throughout the course, I felt that I could be successful in the coursework.

Usefulness

- In general, the coursework was useful to me.
- The coursework was beneficial to me.

Attitude

- The coursework held my attention.
- The instructional methods used in this course held my attention.
- The instructional methods engaged me in the course.
- I enjoyed completing the coursework.
- The coursework was interesting to me.

Future Use

- I found the coursework to be relevant to my future.
- I will be able to use the knowledge I gained in this course.
- The knowledge I gained in this course is important for my future.

To supplement and better understand the data from survey responses, we also intend to prompt students with open-ended reflection questions. These questions have not been finalized yet but are anticipated to elicit students' thoughts related to the meaning of stakeholders and community with respect to engineering projects, as well as their perceptions of the usefulness of the semester

project to identify potential connections between the CAM constructs and the learning outcomes we are focusing on improving.

Discussion

Lessons Learned: Course Development

We found that there was a strong opportunity for alignment between the goals of community engagement projects and the course learning outcomes for the introductory first-year engineering course being studied. Specifically, the authors found that there was potential for improving students' learning experiences with respect to stakeholders and holistic issues, as well as their understanding of how to communicate with an external client by working on these kinds of projects. By introducing project partners who have identified a problem on the campus where the students are studying, we hope to help foster a sense of appreciation for the importance of holistic issues and the broad potential impact of engineering projects. Whereas the authors have observed that students in past years have anecdotally remembered this course as "the MATLAB class," community engagement projects, by putting students in a context where they can see the direct results of their work in researching these broader topics, have the capacity to create a richer learning experience.

Even with the close alignment in the selected course learning outcomes and community engagement goals, some challenges were present when it came to development and revision of existing course learning activities to accommodate the new projects. The instructor of the pilot course found that it required a significant amount of careful planning to discuss things like service-learning, dedicate time for students to engage with their project partners, and prevent student workload from exceeding the course's number of credit hours. In some cases, what initially seemed like a small change, such as changing language in a team startup package to adjust from student-proposed projects to a similarly themed project proposed by campus staff, turned out to have a cascading effect throughout the course schedule due to differences in pacing required by these newer projects.

Lessons Learned: Project Partnerships

We also identified several best practices when developing new project partnerships and developing course-appropriate topics for students to explore in a first-year engineering context. One initial surprising finding was the range of motivations that project partners can have when it comes to working with students. While the intent of a community engagement project is a mutually beneficial outcome for both the partners and students, often it is easy to assume that means the final product, report, or other tangible artifact produced by the students. We found that, at least for the partners of this project, one of their primary motivations was more intrinsic in that they, personally and professionally, wanted to engage with first-year students and be a part of their studies. This finding is consistent with previous studies on a large-scale community-based learning program that found the theme of *personal enjoyment* to be one of the major motivators for external partners to get involved [10]. This was an especially valuable takeaway for first-year projects, given that students often do not have the technical expertise yet at this point in their studies to develop a fully functional solution to a real-world problem.

From a logistical standpoint, the biggest lesson-learned was to start early—especially if working with a group of project partners/sponsors. All the project partners have full-time commitments elsewhere, and a limited amount of time to devote to this activity. Even for partners that had graduated from an engineering program, it took several rounds of brainstorming and iteration to develop project descriptions that had the potential to provide a tangible benefit to the partner while being appropriate for the educational level of the students taking the course (although the prior point mentioned their motivations being intrinsic, it was still important to us to make sure that the projects were authentic for the students). As with many specialized disciplines, it was important for the course instructor to help partners identify areas of expert blind spots, ask probing questions to understand why projects were important, and propose new project descriptions based on those conversations to ensure alignment with the course.

One particularly helpful exercise was to show the project partners examples of student work from past projects to help them understand the level of detail and complexity that they could expect. In the initial meeting, the agenda first covered topics such as the course structure, requested commitment from someone wanting to engage with students, key elements of effective community service project scope, as well as an overview of the course learning outcomes and the educational backgrounds of students who take the course. While these were important to cover, showing the examples of past student projects led to a more engaging conversation about how the course is run and what students do than talking about higher-level items such as learning outcomes.

In the future, it may be useful to approach the project development process as a workshop instead of a series of meetings over the course of several months like we did in this study. Consolidating project brainstorming, expectations, and allowing for immediate feedback and iteration of project descriptions could be more time-efficient for all parties, and furthermore has the potential to allow the process to scale up more easily by centralizing the process.

Future Work

While this paper describes the course development process and our plan to evaluate the effectiveness of implementing community engagement projects, future work will describe the results of the assessment data collection and analysis. We anticipate that students will improve their view of the course across multiple metrics described in the course acceptance model, but this will need to be confirmed following the completion of the pilot semester. Furthermore, future studies may be able to document the lessons learned during the implementation and after the completion of the pilot semester and potential for scaling up these projects in the first-year program at the study institution.

Conclusions

Students often find it difficult to connect with and see the relevance of course learning outcomes that are non-technical in nature compared to the technically focused learning and assessment they are used to. We are investigating whether the incorporation of community-engagement (service learning) projects can improve students' appreciation of these outcomes based on the success of other similar programs. We have identified four phases to this work: course preparation and design, engaging with community partners, implementation of the projects, and

assessment of the impacts on students. In this paper, we have described our experiences on our journey through the first two of these phases and outlined our plans to complete the final two.

We have found that first-year project-based courses, at a structural and learning-outcome level, appear to be well-suited to the incorporation of community engagement projects, while at the same time noting some of the challenges that we faced given the typical scale of these programs and limited knowledge and skills of students at this level. We hope that this experience can assist others with similar interests as the cost-benefit of such implementations can be greatly improved when instructors don't start from scratch and instead resort to the tips and other lessons learned from work like this one to reach out to and nurture connections with partners, manage expectations (including appealing to the personal enjoyment), and foster expedited communication channels between partners and students, and ultimately promote an environment of rich student learning.

References

[1] C. K. Y. Chan and S. W. Chen, "Students' perceptions on the recognition of holistic competency achievement: A systematic mixed studies review," *Educ. Res. Rev.*, vol. 35, p. 100431, Feb. 2022, doi: 10.1016/j.edurev.2021.100431.

[2] D. Lopez, "Using Service Learning for Improving Student Attraction and Engagement in STEM Studies," presented at the 45th SEFI Conference, Azores, Portugal: European Society for Engineering Education (SEFI), 2017, pp. 1053–1060. [Online]. Available: http://hdl.handle.net/2117/113240

[3] N. Evangelopoulos, A. Sidorova, and L. Riolli, "Can service-learning help students appreciate an unpopular course?: a theoretical framework," *Mich. J. Community Serv. Learn.*, vol. 9, no. 2, pp. 15-, 2003.

[4] C. Scherrer and J. Sharpe, "Service Learning Versus Traditional Project-Based Learning: A Comparison Study in a First Year Industrial and Systems Engineering Course," *Int. J. Serv. Learn. Eng. Humanit. Eng. Soc. Entrep.*, vol. 15, no. 1, pp. 18–32, Apr. 2020, doi: 10.24908/ijsle.v15i1.13569.

[5] C. Sevier, S. Y. Chyung, J. Callahan, and C. Schrader, "What Value Does Service Learning Have on Introductory Engineering Students' Motivation and ABET Program Outcomes?," *J. STEM Educ.*, 2012.

[6] E. A. McCrea, "Integrating Service-Learning into an Introduction to Entrepreneurship Course," *J. Manag. Educ.*, vol. 34, no. 1, pp. 39–61, Feb. 2010, doi: 10.1177/1052562909337906.

[7] J. Duffy, L. Barrington, W. Moeller, C. Barry, and D. Kazmer, "Service-Learning Projects in Core Undergraduate Engineering Courses," *Int. J. Serv. Learn. Eng. Humanit. Eng. Soc. Entrep.*, vol. 3, no. 2, 2008, doi: https://doi.org/10.24908/ijsle.v3i2.2103.

[8] L. A. Cooper, D. Kotys-Schwartz, and D. T. Reamon, "Project-Based Service-Learning and Student Motivation," in *ASME International Mechanical Engineering Congress and Exposition*, 2011, pp. 47–53.

[9] B. D. Jones, "Motivating Students to Engage in Learning: The MUSIC Model of Academic Motivation," *Int. J. Teach. Learn. High. Educ.*, vol. 21, no. 2, pp. 272–285, 2009.

[10] J. Thompson and B. Jesiek, "Motivation of Community Partners and Advisors to Participate in Community Engagement Engineering Programs," in *2014 ASEE Annual*

Conference & Exposition Proceedings, Indianapolis, Indiana: ASEE Conferences, Jun. 2014, p. 24.916.1-24.916.13. doi: 10.18260/1-2--22849.