Deepening Engineering Skills Through Community Engaged Learning in a Sustainable Energy Systems Course

Dr. Maija A Benitz, Roger Williams University

Dr. Maija Benitz is an Assistant Professor of Engineering at Roger Williams University. She has a bachelors in Physics from Colorado College, and received her Masters and PhD in Mechanical Engineering from UMass Amherst. Her research focuses on wind energy, ocean engineering, and engineering education.

Dr. Li-Ling Yang, Roger Williams University

Dr. Yang has extensive experience working with both pre-service and in-service teachers in science and engineering education courses and professional development workshops. She has authored conference and journal articles about elementary science curriculum, professional development for teachers, application of visual data in science classrooms, conceptual change, and engineering education. Additionally, she has conducted several grant projects to enhance science and engineering education in K-8 schools.

Deepening Engineering Skills Through Community Engaged Learning in a Sustainable Energy Systems Course

Maija A. Benitz* and Li-Ling Yang^
**School of Engineering, Roger Williams University, Bristol, RI*
^Department of Education, Roger Williams University, Bristol, RI
mbenitz@rwu.edu, lyang@rwu.edu

Abstract

A community engaged learning experience, bridging courses in engineering and education, was established to support the needs of our local school district. The recent adoption of the Next Generation Science Standards in Rhode Island introduced the requirement to include engineering content in the public elementary schools. The school district identified the fourth grade for the pilot year program. Wind energy was selected as a topic area for introducing the engineering design process due to our engineering students' growing expertise in that area as well as its relevance to Rhode Island. Interdisciplinary teams of engineering and education majors collaborated to develop and teach five lessons across eleven fourth grade classrooms, reaching more than 230 fourth grade students. The project culminated with a day-long celebration on our university's campus in which fourth graders tested their model-scale wind turbines in a wind tunnel and completed various engineering design activities. This work focuses on the outcomes of the engineering students (primarily juniors and seniors specializing in mechanical and/or electrical engineering). In particular, the efficacy of this community engagement project as a pedagogical tool for meeting ABET outcomes is examined through survey results and team reflection papers. The impacts on the education majors, fourth grade students/teachers, and university faculty are outside the scope of this paper, though these outcomes are equally important and will be assessed in another study. Qualitative and quantitative results demonstrate overall success of this project upon completion of its pilot year and provide insights for future improvements to the program. Engineering students reported growth in communication, teamwork, and time management, among other skills. The continuation of this community engagement project will provide opportunities for improvement, particularly in the methodology and frequency of student reflection.

Introduction

Service learning falls under the broader umbrella of community engaged learning which is increasingly being adopted as a pedagogical tool for engineering education. Jacoby concisely describes service learning as "a form of experiential education in which students engage in activities that address human and community needs together with structured opportunities intentionally designed to promote student learning and development" [1].

The main components of community engaged learning are service, academic content, partnership and reciprocity, and finally, analysis or reflection [2]. The service should provide support and solutions for overcoming a community identified need, while also deepening students learning of engineering concepts. The community engagement work provides an opportunity for students to apply their classroom learning in a real world setting, with the intention of enriching their understanding of academic content. It is important that the work is done in partnership with the community, and not *for* the community, in a way that is truly reciprocal. Finally, students must reflect on their work before, during and after the experience to process, contextualize, and deepen their learning.

While community engagement projects have been primarily incorporated into first-year curriculum as well as senior design capstone experiences, there continues to be growth in the use of this pedagogy across the entire undergraduate engineering experience [3]. Community engagement projects also occur in extracurricular settings, for example through participation in student clubs such as Engineers Without Borders [4].

The benefits of community engaged learning for course work as well as extracurricular activities are well documented. The pedagogical approach to teaching engineering has a great impact on student learning outcomes and courses that incorporate more active and engaged pedagogies show increases in students' gained knowledge [5]. More specifically, researchers have found that community engaged learning promotes the recruitment and retention of minoritized groups in engineering, including women [3], [6]. Furthermore, students grow in their self-confidence, cultural competency, civic responsibility, creativity, as well as enhance their critical thinking, professional, and communication skills [3], [7], [10]. Finally, this pedagogical approach can support engineering programs in fulfilling criteria set forth by the Accreditation Board of Engineering and Technology (ABET) [3], [7], [8], [9].

While there are numerous advantages to incorporating community engagement projects into engineering curriculum, challenges remain. For example, it is not uncommon to encounter students who are resistant to engage in service learning activities [7]. Additionally, it can be challenging to maintain rigor and depth in the academic content while also meeting the needs of the community partner [8] within the time constraints of the university [3]. Assessment of the project success can also be difficult, Fortunately, scholarship about the evaluation of service learning continues to expand [3]. Despite these challenges, the literature argues that the benefits far outweigh the difficulties.

Assessment Methods

Evaluation of the effectiveness of community engaged learning can take many forms, including surveys, student reflections, validated assessments, and analysis of student artifacts [3]. In many cases, assessment of projects has made use of multiple evaluation tools. For example, to evaluate a community project in which undergraduates taught middle schoolers how to program robots, a mixed methodology using surveys and students' reflections was performed [6].

Student reflection on their experience in community engagement projects is critical to the learning process [1]. It is imperative that students are given the opportunity to connect their service experience to the academic content of the course [2]. Furthermore, reflection allows students to process and identify connections with environmental, ethical, and societal factors.

The components of an effective service learning reflection can be described by the 5 C's: continuous, connected, challenging, contextualized, and coached [11]. The reflection should be continuous throughout project, that is, it should happen before, during, and after the experience. The connection component should link the service experience to the course curriculum. The reflection should challenge students to engage with current issues, while also contextualizing the work in a way that fits the specific project. Finally, coaching is necessary for supporting students intellectually, emotionally and academically.

Student reflections can also be useful tools for the analysis and evaluation of the effectiveness of community engagement projects as a pedagogical tool for student learning [9], [10]. For example, in a sophomore-level measurements lab, students responded to a series of guided questions before and after their community engagement experience. Instructors examined the reflections to explore how students connected the course content with their community work [12]. Reflections have also been used in extracurricular work, such as an Engineers Without Borders (EWB) project in which students complete pre- and post-trip surveys, as well as daily reflections. These reflections were used to evaluate the educational benefits of EWB projects [4].

The community engagement project presented in this research was assessed through an aggregation of survey responses and student reflections. The survey questions and prompts are presented in the Results and Discussion section, below.

Project Overview

This research presents the experiences and findings from implementing a semester-long community engagement project in an engineering elective course titled Sustainable Energy Systems, primarily enrolled with junior and senior engineering majors.

Through a community partnership with the school district near our university, sophomore education majors collaborated with engineering students to educate local fourth graders about engineering design and wind energy. Since the adoption of the Next Generation Science Standards (NGSS) in Rhode Island in 2013 [12], the local district has had a pressing need to provide elementary schools with support for integrating engineering in their classrooms. Wind energy was identified as an appropriate instructional topic, both for its relevance to Rhode Island, and for its strength as a tool for studying the engineering design process. The school district identified fourth-grade teachers and students for participation because the intended instructional topic of wind energy is well-aligned with eight of the 4th-grade NGSS performance expectations and the district science curriculum's units of study for Grade 4.

Interdisciplinary teams of engineering and education majors were established at the start of the semester. Each team was assigned to one of the eleven fourth grade classrooms in the school district for the entirety of the project, shown schematically in Figure 1. The students collaborated closely to develop and implement an integrated science and engineering unit of instruction focused on wind energy. The education students brought their emerging expertise in planning grade-specific and NGSS-aligned science lessons. Meanwhile, engineering students complemented the strengths and knowledge of the education students with their growing mastery of the technical aspects of wind energy.

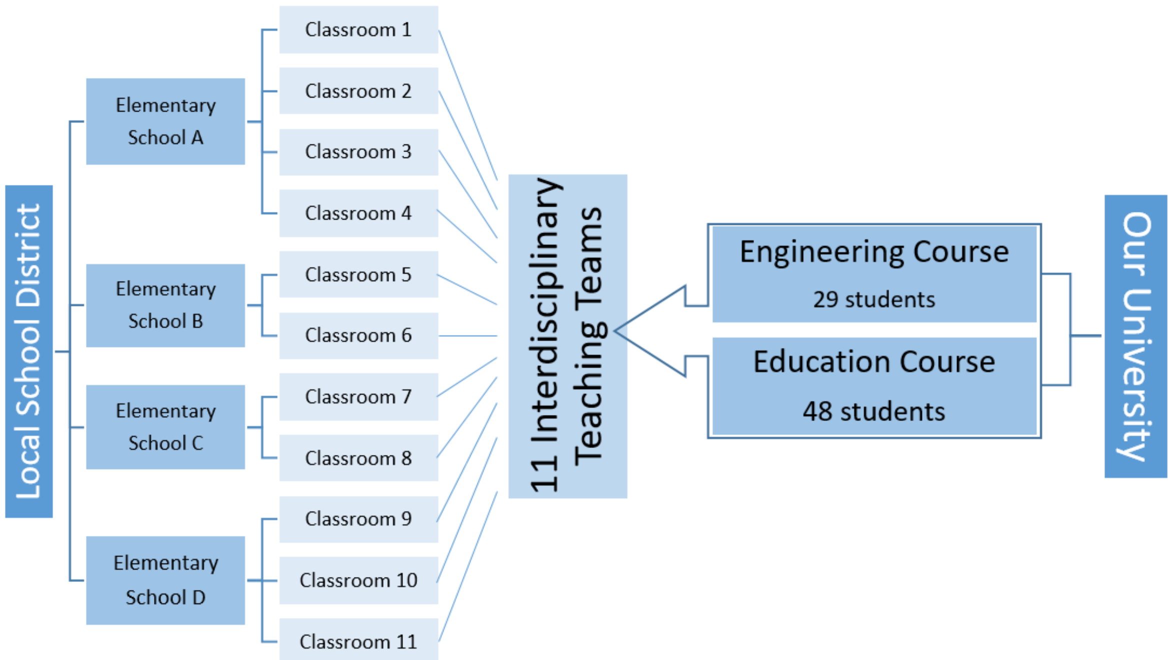

Figure 1: Overview of project organization including the eleven 4th grade classrooms across four elementary schools in which our university's students taught lessons.

The first and second lessons covered energy, energy transformations, and wind. The third lesson introduced the fourth graders to the engineering design process and the KidWind model turbine kits. During the final two lessons, the college students guided teams of fourth graders in using the iterative engineering design process to design, build, and test blades for model wind turbines. Each team of fourth graders was given a model wind turbine kit, developed and manufactured by KidWind and Vernier, which provided hands-on experience with the engineering design process [14]. Each kit contains a tower and base to support a nacelle. A rotor at the front of the nacelle allows students to attach anywhere from one to twelve wind turbine blades with wooden dowels. At the back of the nacelle, students can measure mechanical energy by lifting weights with a spool or electrical energy from a small generator. One of the model kits is shown generating electrical energy during a classroom lesson in Figure 2 (left).

Upon completion of the five lessons in the elementary schools, all 230+ fourth graders in the school district came to our campus to participate in a day-long program focused on engineering design and wind energy. Engineering and education majors co-facilitated the event in which fourth graders rotated through a series of round robin stations. Two stations reinforced the engineering design process through non-wind energy related hands-on activities. Fourth graders also participated in an engineering themed scavenger hunt, and presented their wind turbine designs to a panel of experts from local engineering firm, TPI Composites. Finally, each team of fourth graders tested their wind turbine in a wind tunnel that was designed and built by one of our college students. Fifty-seven model wind turbines were tested, and the results were displayed on a districtwide wind farm poster that could be viewed by all participants. Examples of the finalized designs are shown in Figure 2 (right) as they awaited wind tunnel testing.

To conclude the community engagement project, the interdisciplinary teaching teams created and presented posters at our university's end-of-year academic showcase. Additionally, the engineers from each team collaborated with each other to produce a project portfolio documenting their work.

Figure 2: Fourth graders testing their wind turbine's electrical energy output with guidance from an engineering major during a classroom lesson (left), and model-scale wind turbines with blades designed, built, and tested by fourth graders at the celebration event (right).

Though this project included fourth graders and their teachers, as well as education majors, and faculty in both engineering and education, this research focuses solely on understanding the impacts on the engineering students. Assessment data was collected across the four participant populations; fourth grade teachers, fourth grade students, education majors, and engineering majors. The outcome assessment for the fourth grader teachers, fourth grade students, and education majors is outside the scope of this paper and will be presented in another work.

Results and Discussion

Responses to an end-of-semester survey and students' written reflections from their project portfolios are evaluated from the pilot year of our community engagement project. In particular, the assessment focuses on the project's effectiveness in enhancing skills and fulfilling various ABET (a-k) outcomes [15].

Skill Building Assessment from Student Responses to a Project Survey

At the conclusion of the semester, a project survey was administered to students at the same time as the university-wide course evaluations. The students completed the online survey in the classroom without the presence of the course instructor. Participation in the survey was not incentivized and as such, may explain why it was completed by only 23 of the 29 enrolled students. The survey asked students to reflect on the skills they either gained or enhanced through a variety of question styles, returning both qualitative and quantitative results. The following questions were administered to the students:

1. I gained or enhanced the following skills from participating in the KidWind Community Engagement Project (select as many as apply).
   - Deepened understanding of course material
   - Thinking on your feet
   - Flexibility
   - Listening skills
   - Problem solving and critical thinking
   - Communication
   - Teamwork
   - Learning more about cultures/populations different from their own
   - Understand both assets and needs in communities
   - Apply what you learned in class to a real-world setting
   - Meet others who enjoy serving the community and build personal networks
   - Gain hands-on experience in a community setting
   - Build professional connections useful for future internships or jobs
   - Science communication
   - Project planning
   - Cross-disciplinary collaboration
   - Other: _____

2. What was the most valuable part of the KidWind Community Engagement Project?

3. Whether I liked it or not, the KidWind project was valuable for my learning. (1 = strongly disagree, 5 = strongly agree).

4. I enjoyed the KidWind project. (1 = strongly disagree, 5 = strongly agree).

5. I have added this project to my resume, or plan to add it in the near future.

The student survey responses are shown in Tables 1 and 2, as well as Figures 3, 4 and 5, below. Responses to Question 1 are ranked in order of highest number of positive responses. All of the students who completed the survey indicated teamwork as a skill that was gained or enhanced. The results also indicate that students grew applying course content to a real world setting (95.7%), followed by communication (91.3%) and cross-disciplinary collaboration (91.3%). Ten of the sixteen suggested items were selected by more than 70% of the students, demonstrating that most students felt they had gained or enhanced many skills through their participation in this community engagement project.

However, less than half of the students felt that they gained professional connections that would be useful for future internships or jobs. This result is perhaps not too surprising, as the networking opportunities were restricted largely to the school district, with minimal interaction with professional engineers. Other skills with lower response rates include learning about populations different from their own, understanding the assets and needs of a community, and flexibility. These items demonstrate opportunities for project improvements going forward, for example, through enhancing discussions and reflections about the relationship with the community partner.

Table 1: Responses to Question 1
"I gained or enhanced the following skills from participating in the KidWind Community Engagement Project (select as many as apply)." [n = 23 students]

Gained/Enhanced Skill	**Number of Responses**	**Percentage of Students Who Selected Item**
Teamwork	23	100.0
Apply what you learned in class in a real-world setting	22	95.7
Communication	21	91.3
Cross-disciplinary collaboration	21	91.3
Thinking on your feet	20	87.0
Project planning	20	87.0
Gain hands-on experience in a community setting	19	82.6
Science communication	18	78.3
Listening skills	17	73.9
Problem solving and critical thinking	17	73.9
Deepened understanding of course material	16	69.6
Meet others who enjoy serving the community and build personal networks	16	69.6
Flexibility	13	56.5
Understand both assets and needs in communities	13	56.5
Learning more about cultures/populations different from their own	12	52.2
Build professional connections useful for future internships or jobs	10	43.5

Table 2: Responses to Question 2
"What was the most valuable part of the KidWind Community Engagement Project?"

Results sorted by theme:	**Number of Responses**	**Examples of Student Responses**
Helping/teaching/motivating 4th grader students	13	"Working with young students as a mentor to help them better understand wind turbines and the importance of the blades" "Inspiring fourth graders to learn engineering"
Working with another discipline (education students)	4	"Being able to work with members of a completely different profession" "Learning how to work with others in a different discipline to come together as a group"
Improving my communication skills	3	"Communicating scientific information to an unfamiliar audience (4th grade students)"
Enhancing my resume	1	"How it looks on a resume"

Next, students were asked an open-ended question to learn what they felt was the most valuable part of the community engagement project. Twenty-one students responded to this question, and the results are shown in Table 2, above. Overwhelmingly, students responded that the most valuable part of the project was teaching and motivating the fourth grade students. The responses also show that the engineering students valued working with education majors and growing in their scientific communication skills. One students reported that the project was useful for improving a resume.

Students then responded to two questions on a Likert scale and the results are displayed in Figure 3 and 4, below. Of the 23 students who responded to Question 3, indicating their level of agreement to the statement that the KidWind project was valuable to their learning, twelve answered that they strongly agreed, eight said they agreed, three were neutral and none showed any disagreement. In Question 4, eleven students answered that they strongly agreed with the statement "I enjoyed the KidWind project", while two students agreed, or were neutral, and one student did not agree.

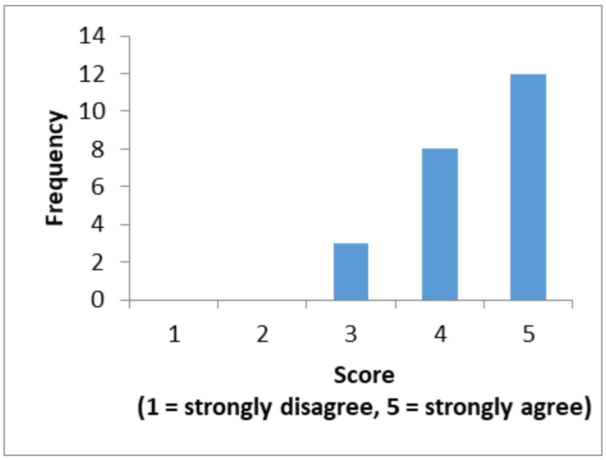

Figure 3: Responses to Question 3, "Whether I liked it or not, the KidWind project was valuable for my learning. (1 = strongly disagree, 5 = strongly agree)." [n = 23 responses]

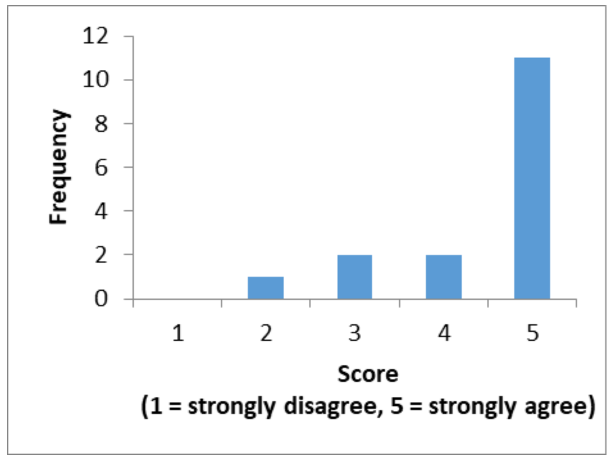

Figure 4: Responses to Question 4, "I enjoyed the KidWind project. (1 = strongly disagree, 5 = strongly agree)." [n = 16 responses]

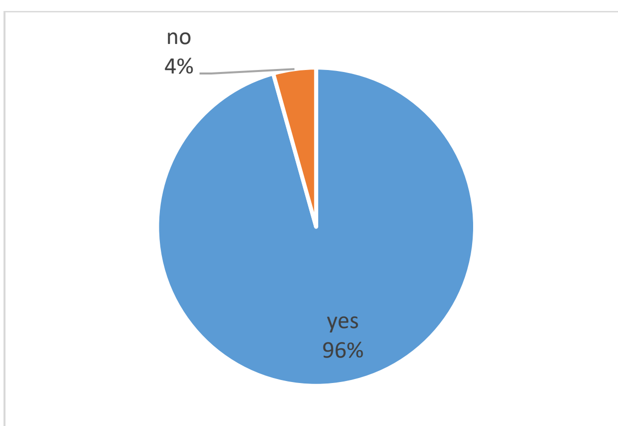

Figure 5: Responses to Question 5,
"I have added this project to my resume, or plan to add it in the near future." [n = 23 responses]

Finally, students were asked whether they added, or plan to add, this community engagement project to their resumes. Of the 23 students who responded, only one was negative. The results are shown in the pie chart in Figure 5, above. Overall, these results demonstrate that even if students did not enjoy the project, they found the learning outcomes to be valuable for their professional growth.

Outcomes Assessment from Students' Project Portfolios and Reflections

For the project portfolios, students were asked to work with the other engineering majors on their teams to create a comprehensive yet concise document summarizing their project accomplishments. The portfolio needed to include a discussion of their project planning and the community partner, a description of learning outcomes, their lesson planning process, and a conclusion. Additionally, it was required that they include an appendix with all of the lesson plans they designed and implemented in the elementary schools, including any worksheets, slides, handouts, exit tickets, and other teaching tools. Students were told that the audience included their instructor, community partner (the elementary school and school district), the university's Community Partnership Center, other University faculty, and future engineering students.

Additionally, students were asked to reflect on the lessons they learned from participating in this semester-long community engagement project, using the following questions as prompts:

- If you could go back to the beginning of the project in February, what would you do differently to improve your project outcomes?
- What do you take away from this project?

Passages were selected from eight team portfolios, comprised of 23 students, to be used as evidence in meeting the accreditation criteria from ABET. Specifically, this research focused on ABET outcomes c, d, g, and h, as they are often deemed as the "softer" and more challenging outcomes to fulfill and provide evidence.

ABET outcome (c) is "an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability" [15]. One team of engineering students reflected on the multi-layered needs of the community partner, exhibiting an ability to identify desired needs in the context of system design.

> Each tier of the community partner had needs that we tried to address through this project. The school district as a whole had a need for more science and engineering curriculum. The elementary schools had even more of a need for engineering because it is known that exposing students to engineering concepts at a young age has a multitude of benefits. Finally, the fourth grade students that we worked with had a need for more hands-on experiences; learning by doing is a great way to engage students of all ages, and this is hopefully something that they will remember as they grow older.

Another team of students discussed the evolving needs of the fourth graders, and their ability to adapt within the constraints of the project. The following passage demonstrates students' ability to implement an appropriate solution to the challenge of maintaining the focus of fourth graders and ensuring their learning.

> Another way the needs of the fourth graders were met was by changing the structure of the classroom. Throughout the lessons, the students were broken up into smaller groups to focus on certain tasks. […] It also prevented loss of information because they did not learn as much at once.

Finally, a different team of students displayed a metacognitive awareness of the fourth graders learning and engagement of the engineering design cycle. Students reflected on their experience of observing fourth graders using engineering vocabulary relating to the design cycle, stating that it was proof of the success of the work.

> […] as a facilitator of one of the stations, I observed students asking where the "research" part of the design process would come from. This shows that they retained the engineering design process and the goal of implementing engineering into these students' lives was successful.

In the semester-end survey, students shared that they had gained or enhanced their skills in working on multidisciplinary teams, which is directly addressed in ABET outcome (d), "an ability to function on multidisciplinary teams" [15]. Reflections from the team portfolios deepened the survey feedback. Multiple teams of engineering students remarked on how rarely they have had the opportunity to work with students outside of their major, aside from the classes they take in the core curriculum, which is primarily completed in their first and second year at the university. Furthermore, students acknowledged the value of this unique opportunity through demonstrating an understanding of the assets of the different team members.

> As engineering majors we don't often work with students who aren't engineering majors […] It was important to understand that each person brought something to the table that could be used to help us complete our goal. The education majors know how to teach fourth graders and the engineering majors know how energy and wind turbines work.

In addition, students showed appreciation for the value of this experience, in that communicating with various discourse communities will be a common practice in their future roles as engineers.

> The experience of working with students in a different discipline than engineering was eye-opening. It is unfortunate but the engineering curriculum does not really allow engineering students to be in class with any students from a different major besides some core classes at the beginning of their college experience. […] The practice of choosing the right language to speak with others outside of engineering will be vital while working in our fields once we graduate and the kid wind project allowed for us engineers to practice that.

Finally, students reflected that working on multidisciplinary teams improved their listening skills and gained open-mindedness.

> In order to make the team work while creating and revising the lessons, we had to be open minded and listen to each other as we had completely different backgrounds and specialties.

Although 91.3% of students reported that they gained or enhanced their communication skills in this project, only three students responded that it was the most valuable part of the project. The student reflections however, contain many passages in which students discuss their growth in various communication skills. The following reflections provide evidence of ABET outcome (g), "an ability to communicate effectively" [15]. The engineering students commented on their communications between multiple stakeholders, including fourth grade students and their teachers, as well as the education majors in their teaching teams. In discussing communication with the fourth graders, two team discussed the need to understand content material deeply in order to explain concepts to audiences of non-engineers.

> Learning how to connect and interact with a younger audience gave boosts of confidence in regards to public speaking and […] in order to teach the material, the engineers had to become extremely familiar with the ideas and be able to answer questions when asked about them.

> [The engineering students] had to adapt to the change in environment in order to explain the concepts to the fourth-grade students in a way they could understand easily. This prepared the engineering students for the real-world workplace where there will be people that aren't engineers but still need to have a broad understanding of the topics.

A different team reflected on the importance of communicating with the community partner for the sake of gathering information to maximize project success.

> […] increased communication with external partners, specifically our collaborative teacher, to [gain a] better understanding of the education level of the students beforehand.

Finally, students commented on the need for effective communication between themselves and their team members from the education department. The passage below is a demonstration of engineering students self-reporting a need to grow in both imparting and receiving information.

> Communication was important in our group to help plan lessons across disciplines. Collaborating with education majors was a big adjustment for all of us […] we needed to be able to excel at reciting our information to them, and also be able to listen in order to confidently write a lesson plan.

Finding supporting evidence for ABET outcome (h), "the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context", can be challenging [15]. Community engagement projects provide an opportunity for students to apply engineering solutions and observe the impacts, first hand. Multiple teams of students reflected on their work in a manner that demonstrated an appreciation for the value of their broader education. For example, one team listed other courses that were helpful to their success in the project.

> Other courses taken that assisted in the preparation of the KidWind project include environmental engineering and physics. These classes provided an understanding of potential and kinetic energy and humankind's impact on the environment. Both of these concepts were useful and implemented into the lessons taught to the students.

Another team directly reflected on how this project fits within an environmental context, and how that informs what they would do differently, if they were given the chance.

> If given more time to continue the development of the project, we would create another lesson to stress the importance of renewable energy and its many sources. Environmental issues are a big

> problem right now and teaching the children about them and how they can help reduce the issues is important.

Aside from ABET outcomes c, d, g and h, various other themes arose in the students' reflections. Many teams remarked that this project improved their time management skills. One team went further by connecting the usefulness of that skill for their future careers.

> One key lesson learned was time management; being able to manage and meet project deadlines is extremely important in the workplace so focusing on delegating work and breaking it down into smaller manageable sections is key.

Multiple teams also brought up the importance of flexibility and "thinking on your feet" when carrying out this community engagement project.

> The first lesson that we had to learn was how to think on our feet. With so many kids and so little experience managing everyone it was important that we were able to improvise if an activity or lesson wasn't going according to plan.

> Another aspect we initially overlooked would be adaptability. Even though we planned out every lesson plan hiccups occurred which had us change the delivery on the spot.

Conclusions and Future Directions

This community engagement project proved to be a successful pedagogy for fulfilling ABET outcomes, in particular outcomes a, d, g, and h. Engineering majors grew in their teamwork, communication, and time management skills through collaborating with education majors to design and deliver five lessons on engineering design and wind energy to fourth graders. Project reflections and end-of-semester surveys indicate that the project was successful in developing and enhancing professional skills for the engineering student participants, without the loss of accomplishing course learning outcomes. By the end of the project nearly all students felt that the project was worthy of being added to their resumes. Feedback from students was overwhelmingly positive, despite any initial reservations about teaching elementary school students.

The pilot year of this project was not without challenges, which we seek to overcome in the future implementations of this work. The issue of student resistance to this type of project could be minimized with increased transparency. For example, by introducing students to the project before the start of the semester, through a pre-semester email and calling-out the explicit purpose of the work as a tool for learning, in addition to supporting the needs of the community partner. From a project evaluation perspective, this work would benefit from the use of validated assessments. Finally, we plan to incorporate more individual reflection activities before, during, and after the project to enhance students' growth and self-evaluation.

Acknowledgments

The authors would like to acknowledge their research assistants for their work on this project; Tess Alexandre, Kristen Brien, Barry Dunn, Olivia Ryan, and Nathan Wilson. This work was supported by grants from the Hassenfeld Community Projects fund and the RWU Foundation to Promote Scholarship & Teaching, as well as a gift from TPI Composites in Warren, RI.

References

1. B. Jacoby and Associates (1997) *Service Learning in Higher Education.* San Francisco, CA: Jossey-Bass, 1997.
2. G. Bucks, W. Oakes, C. Zoltowski, F. Rego, and S. Mah. "Facilitating Multidisciplinary Teams in a Service-Learning Environment," *in Proceedings of ASEE Annual Conference and Exposition, 2007.*
3. A. Bielefeldt, K. Paterson, and C. Swan. "Measuring the Impacts of Project-Based Service Learning*," in Proceedings of ASEE Annual Conference and Exposition, 2009.*
4. M. McCormick, C. Swan, and D. Matson. "Reading Between the Lines: Evaluating Self-Assessments of Skills Acquired During an International Service-Learning Project," *in Proceedings of ASEE Annual Conference and Exposition, 2008.*
5. J. Segalas, D. Ferrer-Balas, and K. F. Mulder. "What do engineering students learn in sustainability courses? The effect of the pedagogical approach," *Journal of Cleaner Production,* 18(3), pp. 275-284, 2010.
6. P. Bhounsule, D. Chaney, L. Claeys, and R. Manteufel. "Robotics service learning for improving learning outcomes and increasing community engagement*," in ASEE Gulf-Southwest Section Annual Conference, 2017.*
7. A.R. Bielefeldt and M. Lima. (January 21st 2019). "Service-learning and civic engagement as the basis for engineering design education [Online First]", IntechOpen, DOI: 10.5772/intechopen.83699. Available: https://www.intechopen.com/online-first/service-learning-and-civic-engagement-as-the-basis-for-engineering-design-education. [Accessed May 23, 2019]
8. S. M. Lord, E. Tsang, and J. Duffy. (2000, June), "Service learning in engineering: What, why, and how?". 2000 Annual Conference, St. Louis, Missouri, June 18-21, 2000. Available: https://peer.asee.org/8694. [Accessed May 23, 2019]
9. B. Ropers-Huilman, L. Carwile, and M. Lima. Service-learning in engineering: A valuable pedagogy for achieving professional standards. *European Journal of Engineering Education*, vol.30, pp. 155-165, 2005.
10. L. Petry, M. Pinnell, M.S. Franco, B. Doudican, A. Mian, and R. Srinivasan. "Collaborated community-based research experiences in materials and manufacturing," in Proceedings of ASEE Annual Conference and Exposition, 2017.
11. J. Eyler and D.E. Giles. *Where's the Learning in Service-Learning?*, San Francisco: Jossey-Bass, 1999.
12. I. Basolo, J. A. Toft-Nielson, and S. D. Evans. "Engagement in practice: Academic service in a sophomore-level mechanical engineering measurements lab", in Proceedings of ASEE Annual Conference and Exposition, 2018.
13. Rhode Island Department of Elementary and Secondary Education. *RI state science standards*, 2018.
14. "KidWind Products for Renewable Energy." Vernier, www.vernier.com/products/kidwind/.
15. Accreditation Board for Engineering and Technology (ABET). *Criteria For Accrediting Engineering Technology Programs*, October 2017. Available: abet.org.