Board 381: Serving Community Needs while Sharpening Engineering Skills

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Abstract

This paper reports on a novel experiential course, Service Learning in STEM, which aimed to create opportunities for students to apply their technical skills to community-based problems. The course has been piloted as part of the Women In Science and Engineering (WISE) Honors program. Incorporating service projects as part of required curriculum ensures that all students have access without the burden of additional credit hours. Moreover, the innovative partnership with career services has brought a diverse group of non-profit agencies from the local area to the program through its existing relationships. Agencies present their projects and students choose; 5-6 teams are assigned to each project. Projects vary from term to term. Examples include: coordinating Hack-a-thon on 3D modeling, creating digital tools to spread awareness on human trafficking, building a trebuchet by using mechanics and physics behind it, building a balloon powered cardboard car or constructing a digital map for circular economy programs to divert waste from landfills. Weekly meetings between agency and team are coordinated by a student team leader and held to co-develop the process, deliverables, timeline and implementation plans. Students complete bi-weekly personal journal reflections to unpack their experience throughout the term. Projects are presented at the end of the term with agency representatives attending. Peer evaluations are conducted, as well as periodic surveys and focus groups to understand the efficacy of the experiences for both students and community partners. Students report high satisfaction with the experience, pointing to several gains: deeper understanding of the plight of communities in need (e.g., homeless, seniors, underprivileged kids), skills they honed during the project (e.g., essential skills such as organizational, communication, presentation, teamwork, creative problem solving, perseverance, leadership), and technical skills (e.g., project design, data collection, analysis, visualization, project management), along with the feelings of pride and personal fulfillment from the intrinsic rewards of seeing their positive impact. Community partners appreciate the intensive project work, and the deeper connections they make with the institution. While feedback from students and community partners is overwhelmingly positive, a surprising finding was that students prefer educational and social justice projects (~78%), not necessarily those involving highly technical problem solving. Future iterations of the offering will require deeper interrogation of these preferences.

Introduction

There is a critical need to research and implement innovative interventions for retention and career readiness of underrepresented students in science, technology, engineering and mathematics (STEM) [1,2]. In 2017, a four-year curriculum was developed to elevate an existing support program for undergraduate women in STEM into an academic honors program. This renewed Women In Science and Engineering (WISE) Honors program at Stony Brook University (SBU), a public research institution, recruited its first new cohort in 2018. The purpose of this paper is to present formative findings of the research and evaluation plans that examined the effectiveness of one of the new courses, WSE 381: Service Learning in STEM.

Theoretical Foundation

High-impact practices, the educational strategies employed by institutions of higher education, are well known to contribute positively to student engagement and success and have both cumulative and compensatory effects [3]. Service-learning is an established high-impact practice and has shown to contribute to a deeper understanding of community needs as well as deeper subject knowledge [4]. Traditionally engineering curricula have employed service-learning courses less frequently [5], however, recent research suggests that faculty are embracing this pedagogy as an effective means of applying engineering knowledge to assist community partners with challenging problems [6].

Curriculum Description

WSE 381: Service-Learning in STEM is a one-credit course for juniors and seniors designed to integrate meaningful community service within the context of STEM, enriching the learning experience, and strengthening communities while promoting student's sense of civic responsibility. Students' teams pair with community partners to work on a community need. Solutions are evaluated based on the students' understanding of the community context and need, the STEM aspects of the proposed solution, and their communication skills with the community partners.

The course was developed in partnership with the university's Career Center, which oversees a large community engagement program, including volunteer opportunities, internships, part time jobs, and career mentoring. The inclusion of professionals on campus with the extensive network of contacts and expertise in working with community partners was a key component of the plan. Moreover, engaging student affairs professionals in the provision of this community-focused academic program adds value to our efforts in dismantling the organizational silos that limit our ability to leverage expertise and relationships across the campus [7].

Community Partner Outreach

A primary goal of the course is to forge meaningful partnerships between nonprofit organizations, college students and the university through impactful service-learning projects. Our approach involves personalized outreach to non-profit contacts established through the Career Center's long-term partnerships, showcasing the mutual advantages of participating in service-learning projects. We emphasize the unique skills and perspectives that WISE students bring to the table, offering fresh insights and dedicated time to support nonprofit missions.

After gauging initial interest, we conducted meetings with individual nonprofits to discuss the structure of the semester, possible project ideas, timeline, commitments, and expectations. Through communication with each agency, we highlight the potential impact of service-learning collaborations, emphasizing mutual benefits of meeting community needs while providing students with hands-on experiences aligned with their academic goals. We strive to create a symbiotic relationship where nonprofits benefit from the passion, energy, and scientific background of WISE students.

College students engaging in service-learning projects with non-profit agencies represent a powerful force for positive change. These collaborations extend across a diverse array of

agencies and causes, addressing critical societal needs. From tackling hunger through food distribution initiatives to providing essential academic support for underserved communities, students actively contribute to fostering literacy, thereby opening avenues for lifelong learning.

Throughout the past four years, we worked with leading educational consulting organizations that provide a wide range of innovative learning strategies that bridge in-school and out-of-school learning opportunities for underrepresented students, agencies supporting elderly populations or dedicated to reducing the number of people experiencing homelessness.

Furthermore, service projects extend into second language education programs, fostering cultural understanding and communication. In the realm of STEM education, college students play a pivotal role in inspiring the next generation of scientists and innovators. Through their dedication and involvement, students not only enhance their own skill sets but also contribute meaningfully to the betterment of society, embodying the transformative impact of education and service combined.

The Project Experience

In the first four weeks of the semester, community partners present their agencies, services, and projects to the class. Students are expected to conduct research on all organizations and come prepared with questions for the agencies. After, students sign up for a specific project in teams of three or four. Each team designates a leader who will serve as the liaison to the agency for the rest of the semester. Examples of projects include: coordinating STEM Olympiads, Hack-a-thon on 3D modeling, creating digital tools to spread awareness on human trafficking, building a trebuchet using mechanics and physics, building a balloon powered cardboard car or constructing a digital map for circular economy programs to divert waste from landfills. Weekly meetings between agency and team are coordinated by the student leader and held to co-develop the process, deliverables, timeline and implementation plans. When students engage in service projects that involve utilizing new technical platforms, it is essential to ensure they have the necessary training to do so effectively. In such cases, nonprofit agencies often play a vital role by providing specialized training sessions tailored to the needs of the students. For instance, if students are tasked with conducting webinars on a particular topic using a new technical platform, the nonprofit partner offers comprehensive training sessions to familiarize them with the platform's features and functionalities. By collaborating with non-profit agencies in this manner, students gain valuable skills and confidence, enabling them to execute their service projects with proficiency and impact.

Students complete bi-weekly personal journal reflections [8] to unpack their experience throughout the term. Projects are presented at the end of the term with agency representatives attending. In the dynamic process of service learning, students embark on a transformative journey encompassing five key stages, adapted from Kaye [9]: Stage One: Investigate Community and Self, where students delve into understanding the needs of their community and reflect on their own experiences and perspectives. Building upon this foundation, Stage Two: Plan Service Projects and Prepare for Action involves strategic planning and preparation, ensuring that students are equipped to make a meaningful impact. Stage Three: Take Action and Implementation marks the pivotal moment when students actively engage in service,

implementing their plans to address identified community needs. Following the hands-on experience, Stage Four: Reflect on Process and Impact encourages students to critically analyze their journey, reflecting on both the process and the impact of their service. Finally, in Stage Five: Demonstrate to an Audience, students share their insights and experiences with community partners and their peers, fostering awareness and inspiring others to embark on their own service-learning adventures. Together, these steps create a comprehensive framework for students to not only contribute to their community but also develop a deeper understanding of themselves and the transformative potential of service with connection to STEM.

Results

In addition to the personal journal reflections, peer evaluations are conducted, as well as periodic surveys and focus groups to understand the efficacy of the experiences for both students and community partners. Initial student reflections surfaced some anxiety about working in teams and interacting with professionals, however, as the term progressed, students expressed appreciation for the structured service project which prompted them to unpack concepts about poverty, homelessness, disability, health challenges in ways not covered through their engineering curricula. Instructors validated these learnings, and pointed to improvements in student professionalism, written and verbal communication, and teamwork at the end of the term. The value of journaling for the rich descriptions of the student experience is consistent with previous research [10].

Evaluations showed that students report high satisfaction with the experience, pointing to several gains: deeper understanding of the plight of communities in need (e.g., homeless, seniors, underprivileged kids), skills they honed during the project (e.g., essential skills such as organizational, communication, presentation, teamwork, creative problem solving, perseverance, leadership), and technical skills (e.g., project design, data collection, analysis, visualization, project management), along with the feelings of pride and personal fulfillment from the intrinsic rewards of seeing their positive impact. Several students mentioned their delight creating fun learning experiences for kids to get excited about STEM. While not a goal of the course, one student was offered a full-time technical role with one of the project sponsors.

Challenges were faced as well. Most common challenges reported by students were not agency related at all; they centered around group process, team communication, and time management, vis-a-vis balancing the need to complete a class project with the feeling of wanting to fully invest in the project and the agency's mission. These challenges are consistent with a recent meta-analysis of 120 studies of community work as part of engineering education, which found these overall challenges across a wide range of situated community projects: logistics of engagement (time management, travel, calendaring, etc.), communication and cultural understanding, and disconnects between some projects and traditional engineering content [11].

Noting that two of these cohorts performed their service during the COVID pandemic, we believe that embracing remote work in service learning introduces a dynamic and adaptable approach that aligns with the evolving landscape of professional environments. Conducting service learning projects remotely not only offers students flexibility but also exposes them to the digital tools and collaboration platforms widely utilized in today's workforce. By engaging in

virtual service projects, students develop crucial skills in remote communication, project management, and independent problem-solving—essential competencies in the contemporary workplace. Moreover, remote service learning broadens the scope of community impact, allowing students to contribute to projects and initiatives beyond geographical constraints. This practice not only reflects the realities of a globalized world but also empowers students to harness technology as a tool for positive change, preparing them for the demands of a modern, interconnected professional landscape. Because of the ability to work remotely, during one of the semesters, students worked with an organization from another state and were able to assist elderly population with lessons on technology. Being able to conduct meetings with community partners remotely saves time for agencies as well, eliminating the necessity of driving to campus from far distances so it saves time and money.

Assessment

Our assessment and evaluation plan was informed by best practices in internships [12] and lessons learned from the service learning literature [10]. The plan includes surveys of students' interests, reviews of their journals, evaluation of their solution by the community partner, and student learning assessments.

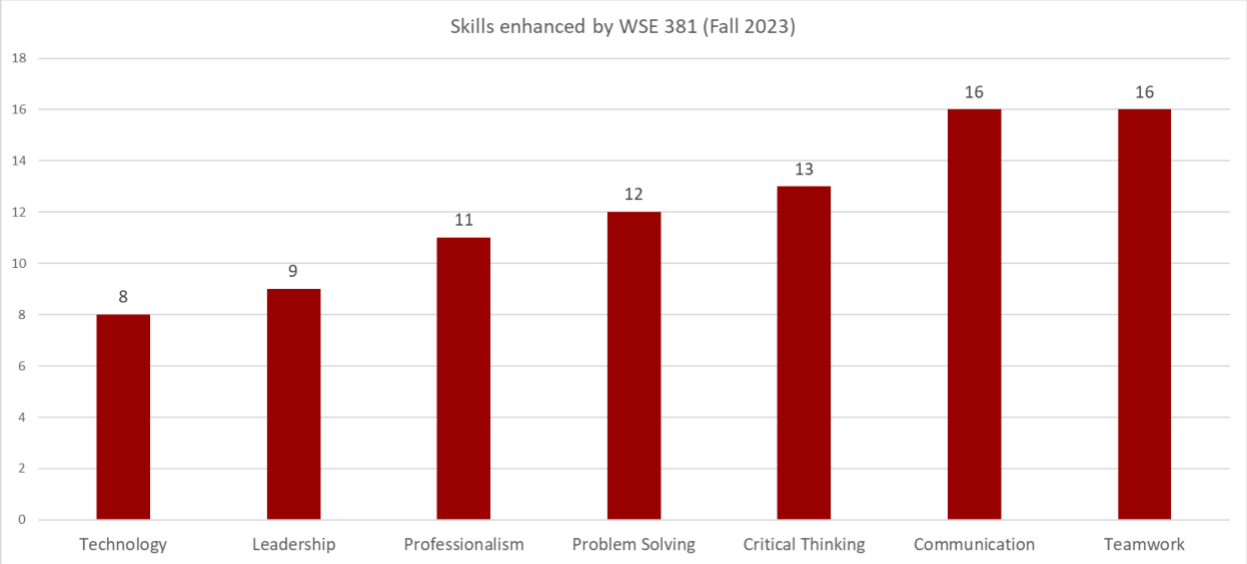
Student Understanding of Service Learning
In response to questions about the definition of service learning, students often made a connection to developing skills in the STEM field.

> *"My definition of service learning is learning soft skills through service, and reflecting upon experiences in service. Service-learning allows for the development of much needed soft skills in STEM fields. I think service learning reminds us of our motivations in developing STEM fields."*

> *"The very purpose of advancement in STEM fields is to understand our world better so we can make a better world to live in. There is no better way to do that than hands-on experience in service-learning."*

Student Interest
At the beginning of each semester, we assess student interests to evaluate the population they're interested in working with, the causes they want to support, and the skills they aim to develop. Results overwhelmingly show students' interest in education and working with children and youth (over 40%); these surveys are used to select agencies.

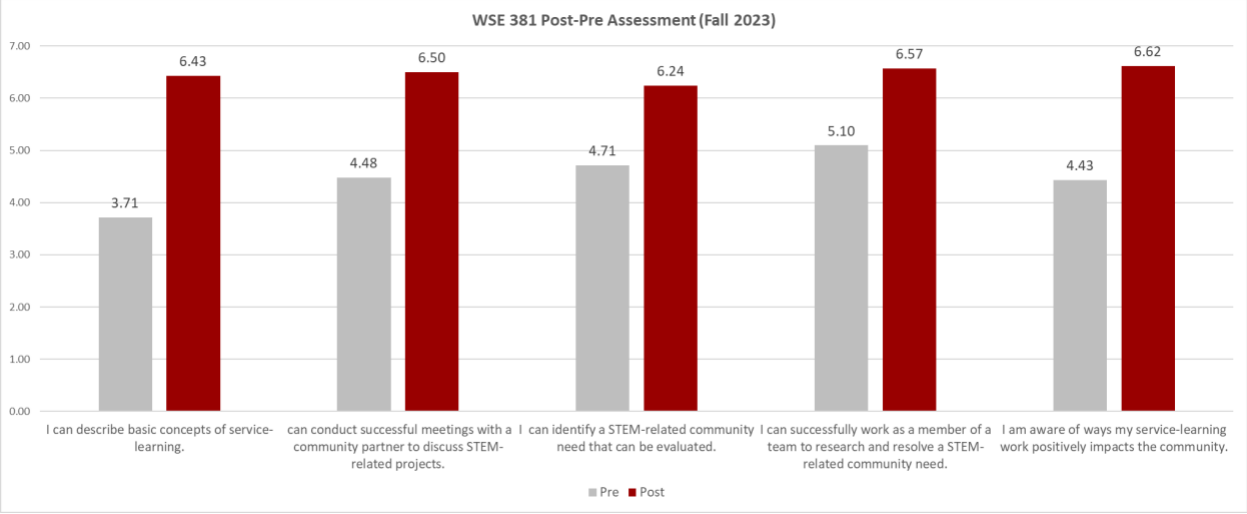
In terms of skills, most students express interest in acquiring problem-solving, communication, and leadership skills, which align precisely with the skills obtained through service-learning experiences [12,13]. Indeed, students are acquiring these skills, as noted in the Fall 2023 end of term assessment below.



Student Learning Assessments

At the end of the semester, students completed post-pre, or reflective pre-post [14,15,16] learning assessments. Results indicated higher understanding of service learning concepts, improved ability to conduct professional meetings on a higher level and work in a team environment. Below are the aggregated responses for students over three semesters.

The Fall 2023 Cohort reported an average increase of 1.99 points across all categories, equating to a 44.76% increase.



Highlights of the experience as shared by students:

- Working with outside organizations
- Hands-on practical projects
- Working with communities
- The ability to choose the organization they work with
- 100% of respondents were proud of their accomplishments in WSE 381

Improvements suggested by students:

- Projects should be started earlier in the semester
- Clearer communication about outside-of-the class work/meetings
- More frequent check-ins/benchmarks

Community Partner Feedback

Community partners were very satisfied with the quality of the students' work, their interactions with the student leaders and teams, and with the communication from the instructor. Moreover, they indicated that student teams demonstrated positive attitude, professionalism, and strong teamwork skills. In terms of improvements, partners suggested that students could continue to improve their interpersonal skills, communication skills, and time management.

> *"The Murder Mystery Workshop the WISE students conducted for us was wonderful! All of the participants were engaged and enthusiastic. We were also able to create a video that we will utilize in the future for promoting what we do!"*
>
> *"Really great group of students. They worked hard, and together really made a huge impact."*

At the conclusion of the semester, community partners expressed strong consensus that they had expanded the range of services provided to their clients, successfully finished projects that the department had been struggling to complete, and received from students a product with a lasting impact.

Adaptations

In addition to the pivots we made in response to the COVID pandemic, feedback we received from students and community partners enabled us to make changes for improvement.

For example, transportation always presents obstacles for students without cars, and while fully remote options might be a simple solution, there is value in having the students visit the site, meet people in person, and observe the community programming and services that are delivered on site. As we emerge from COVID restrictions, we are exploring a combination of remote work and select visits to the site.

Another enhancement we are implementing in spring 2024 is to carve out class time for students to work on projects with teammates, alleviating the need for additional time commitment outside of class, and ensuring that all team members can be present to make their contributions. We also aim to incorporate more activities in class that create opportunities for students to present their works in progress so other students can contribute ideas and more importantly, be exposed to a variety of pressing community needs.

As students want additional ways to sharpen their skills, we are reducing the number of journal reflections and replacing them with asynchronous simulation modules connected to social impact, project management, and effective communication in the workplace.

Lastly, as requested by students, we are incorporating regularly scheduled check-ins throughout the term between the teams and the agency representatives. It's important to note that the course is structured in a way that maximizes efficiency and minimizes the need for additional meetings outside of class time. We dedicate designated class time specifically for working on projects, allowing students to make significant progress during scheduled class time. Additionally, student teams facilitate regular meetings with agency partners during class time to ensure effective communication and collaboration. By integrating project work and partner meetings into the curriculum, we aim to streamline the process and optimize the use of students' time, ultimately providing a balanced and manageable workload for everyone involved.

Future Considerations

While we survey students each term about their interests, we have not yet dug deep into the motivations that STEM students have for service, and more specifically, why they choose the type of service project (i.e. social justice project or technical project). We aim to incorporate new survey questions and host a focus group led by an external facilitator to delve into these motivations more deeply. We also aim to explore possible long-term community benefits that might be realized from community partners who return.

Conclusion

Integrating service learning into a STEM program for college students can be a rewarding and enriching experience. Following are some recommendations for those seeking to replicate this program: First, look to the stakeholders on your campus with existing community relationships and expertise; engage them in your project to maximize the full range of campus connections with community partners. When exploring community needs, focus on those groups that could benefit from STEM related projects and skills. Such projects would allow students to apply STEM skills in an authentic setting while ensuring tangible impact for community partners. Third, consider ways to infuse professional development in the projects. In our situation, we utilized Forage industry simulations, and have access to a range of programming through the Career Center. Lastly, while individual reflections are effective, consider also creating a space for students to engage in shared peer reflection [17,8] to reinforce student understanding of community needs and more fully deconstruct the experience and surface students' personal values among trusted peers.

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