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Engagement in Practice: Community service builds excitement in design

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Introduction

The Mechanical Engineering Department at Ohio Northern University developed a Bioengineering Concentration in 2016, but for several years had no professional society to support students interested in the biomedical or biomechanics areas. In order to fill this gap, an engineering faculty member solicited student interest in such a group, and found a number of surprisingly passionate students ready to take ownership of and run with this idea. Engineering students chartered the "Biomedical Sciences Design Team" (BSDT) in the fall of 2019, and invited nursing students from the School of Health & Behavioral Sciences to join them.

This team desired to exercise and grow their skills through practical application to benefit the community. The team advisor initiated a partnership with the Hardin County Board of Developmental Disabilities, and the Simon Kenton School operated by this board. The advisor has a son attending the school, which helped to facilitate the introduction, and the student team met with school staff to offer their services. The students helped the staff articulate and define issues that they face in their job, issues that the staff sometimes "didn't even realize had a possible solution." [1]

From these discussions, the team defined three initial service projects that are highlighted in the paper. One is a fine motor skills training toy, designed to develop the small-muscle coordination of children with special needs. The second project is an adaptive table to help a wheelchair-bound student to reach kitchen tools in a kitchen-setting classroom. The third project is an improved cleaning/drying system for gastronomy tubes ("G-tubes") used in the feeding of some students at the school.

The BSDT has other ongoing projects that are not detailed in the paper. One of these is a gripping device designed for elders who are losing hand strength. This will be a wearable device, similar to a "slap bracelet," so that it is always handy and less likely to be misplaced. It is designed to help users with opening doors, jars, or other tasks where additional grip will be beneficial. Another current project is for the local YMCA, which is interested in a sturdy, foldable frame designed to support disabled adults while their caregivers change them into a swimsuit.

This experience has highlighted the power of benevolent activities to foster enthusiasm in community service and engagement. It has also made clear the value of these activities in "problem finding," or "empathizing," [2] a key facet of the problem framing step of the design process. The paper will present details of the service projects, the associated Engineering Projects in Community Service (EPICS) course, student impact, and lessons learned to assist others who may be contemplating this type of activity.

The context of this paper is Ohio Northern University (ONU), a small private undergraduate institution in the Midwest U.S. The ONU College of Engineering houses 645 students in five majors, representing 20% of the university enrollment and approximately half the size of the College of Arts & Sciences. Relevant to this paper, there are 110 students in the nursing program and 193 students in a biology major.

Problem Finding

Jeff Ota, Senior Director at Rivian Automotive, shared his perspective in an interview that "an engineer's fundamental role is to make life better through the application of science and technology." [3] That role is a powerful motivator for many in the engineering field – as well as for many students who are looking toward their own roles in engineering. Modern examples abound of engineering solutions which have made life better, where the public could not articulate the need for such a solution until it was presented to them. This team and the projects it seeks out represent a powerful educational tool to introduce students to this type of process.

Such was the case for the newly-formed Biomedical Sciences Design Team in 2019. Armed with a desire "to make life better" for the staff and students at Simon Kenton School, training in the design process, and technical skills in engineering, nursing, and manufacturing, the BSDT founders visited the school to find needs that they could fill. They spoke with teachers and therapists, and observed the students and immersed themselves in the classroom environment. As the idea generation phase progressed, some of the school staff acknowledged that the conversations helped them unpack issues that they and their students face, and opened their eyes to various means of mitigating these issues.

With the scope of the initial projects defined, engineering students on the BSDT reached out to the nursing and public health departments on campus to recruit additional team members. Nursing professors were very supportive in allowing a BSDT representative to give a talk to their classes about the team and the projects. The resulting participation of nursing students in the projects, as cited below, was critical to the success of at least two of the projects.

The projects thus far completed, detailed below, are neither technically nor mechanically complex. But they are nonetheless examples of the power of community service to motivate

learning, helping students to understand the experience of the user for whom they are designing, and the power of the engineering design process to help other community servants to more fully and efficiently fulfill their own missions.

Motor Skills Board

One project developed by the BSDT was a board providing the opportunity for students to practice an array of normal life activities that require a certain amount of manual dexterity. This custom-built board, pictured in Figure 1, includes a number of clothing features, tool features, as well as some simple fun activities.

Figure 1. Motor skills board

The clothing features include Velcro, a web belt, snaps, buttons, safety pins, a zipper, and shoe laces. Other board features that model interactions with tools and other hardware include a crank, screwdriver, wrench, hasp, hinged lid, keyed padlock, combination lock, faucet, and a doorknob. Finally, activities such as rotating gears, a tile-moving puzzle, and a Simon™ memorization toy[4] are included for simple entertainment. Not all of the available modular activity blocks are pictured.

Each of the orange or white activity squares were 3D printed by students in the Makerspace. These are easily replaced or reconfigured as needed to suit a particular student. One simply opens the hinged back to slide new activity squares in or out.

During the design phase for this project, a nursing student team member invited the engineering students to visit a long-term care facility where she had worked. There the students were able to discuss and test some of their motor skills concepts with a person with polymyositis, a condition causing muscle deterioration. The motor skills board could be adapted for use with this type of

patient and used as therapy to enable her to retain fine motor skills for as long as possible. The nursing student's 11-year-old daughter also became a testing resource, as the board could be a tool to help her with her own occupational therapy goals.[5]

Adaptive Table

Another BSDT project was designed for a specific student in a mobility scooter. This student very much enjoys participating in the kitchen activities at the school, but the counter height and lack of accessible space underneath it has made it awkward for him to do some of the food preparation tasks. Multiple students at the school are confined to a wheelchair of some sort. School staff are excited that this table will enable all such students to more fully participate in kitchen activities.

The team worked with the student to determine an ideal height and location for the table. It will attach to an existing cabinet, and lock down out of the way when not in use. This custom table, shown in Figure 2 in the kitchen where it will be used, is manufactured, assembled, and ready for installation, but has not yet been mounted in place.

Figure 2. Adaptive table

G-tube Drying Rack

The third project involved the cleaning and handling of feeding tubes, or gastronomy tubes (G-tubes) required for those who are unable to swallow or otherwise intake food through their mouth. After each use, the tube must be flushed by forcing water through it, and then drip-dried before being refrigerated to retard bacterial growth. The school had no current students with this need, but have a prospective student who uses G-tubes and the staff was anticipating the need. The staff had envisioned cleaning the tube by injecting water with a syringe. They had no good

place to drip-dry the tubes after cleaning that would keep them clean and out of the reach of other students.

A nursing student was also a key team member for this design project. She was able to contribute knowledge directly, and access nursing professionals with more complete knowledge, regarding the use of G-tubes and the appropriate cleaning and storage standards and processes.

Originally, the students planned to tackle both the cleaning and drying aspects. They worked to design a funnel that would attach to the faucet in the classroom and push water more quickly and forcibly through the tube than could be accomplished with a syringe. After some work on this, they discovered that the faucet in question did not have accessible screw threads for securing the nozzle/funnel, and that the shape of the faucet and sink did not really allow for such a device.

Thus, the project became focused on construction of an appropriate drying rack. The rack pictured below hangs on a cabinet door, allowing water to drain before the tubes go into refrigerator storage. Two such feeding tubes are shown in the pictures below.

Figure 3. G-tube drying rack

Student Impact

The students involved in the Biomedical Sciences Design Team speak about their experiences in this new group with enthusiasm. The BSDT "intrigued me … because I had chosen nursing as a

career path in the hopes of being more beneficial to those around me and making a difference to as many lives as possible," said one nursing student.[5] She notes that this team enabled her to do that in a way outside of traditional nursing. "I look forward to working more with [engineers] in the future!"

As a new group, the students were free to organize the team however they chose. "The chief excitement was being part of a group exercising their engineering skills to satisfy real community needs, where everyone *wanted* to be part of it," said one group leader. "The goal was improving the lives of people in need, rather than an artificial design task done only for a grade and perhaps teamed with some students who would rather not be there."

Another founder of the team said, "I like the opportunity to reach out to the community and design something to make an impact. This club gives me an opportunity to get hands on experience in design and manufacturing before I would have in classes and gain experience" as an underclassman. "Delivering the products, in the face of all the [COVID-related] challenges we faced, has been very rewarding."

A junior electrical engineering student appreciated the "eye opening" (problem finding) aspect of the team's mission. "I've enjoyed getting experience working on real-world engineering problems, as well as finding projects from the surrounding community."

As an all-volunteer team, they clearly take pride in these products, doing their best because they want the product to serve its user as well as possible. The experience was also engaging – and daunting – for them "because the bulk of the immediate feedback on their design ideas came from our peers, not professors." Some group meeting sessions were dedicated to design reviews for the various project teams, where one team would present their proposal to the whole group for suggestions and constructive criticism. "The stakes are so much higher than on a class assignment," said one team member, "because it's not just about a grade. We want our customer to be happy with it, and we really want it to work well."

EPICS Course

EPICS, or Engineering Projects in Community Service, was founded at Purdue University in the fall of 1995.[6] The organization website at Purdue describes EPICS as "a service-learning design program in which teams of students partner with local and global community organizations to address human, community, and environmental needs." ONU adopted this program fifteen years ago, implementing it generally as a one-hour graded course, with different course sections focused on different projects.

In order to facilitate structure and regular progress on the BSDT projects, the team advisor formed a one-hour EPICS course. This course has enrolled between 7-11 students each term since its initial offering in the spring of 2020. The total number of students participating in projects with the BSDT varied a lot during the pandemic, but in better times has averaged 12-20, roughly double the number enrolled in the EPICS course.

The catalog description for this course at ONU is a "service-learning design course in which teams of students work together on long-term projects that address the engineering and/or computing needs of a community partner." Examples of projects:

- The design and installation of a new concrete base for a war memorial cannon in the park of an area village.[7]
- Design improvements to a lunar rover replica built by a previous ONU engineering capstone project for the Armstrong Air & Space Museum.
- Restoration of a 1300-lb bell from a fire-damaged church.[8]
- Boundary survey for a nature center.
- Caboose restoration for village park.
- Design and construction of various occupational therapy devices for children.
- Site development for local high school (space reclaimed from defunct wind turbine).

Any engineering instructor can initiate his or her own section of the course, only requiring a service project description approved by the Dean's Office. Though the course does not satisfy any graduation requirements, the graded course structure does perhaps serve to foster a higher level of accountability to the project, and gives students recognition for the work that will appear on their transcript.

Lessons Learned

The first challenge cited by the BSDT faculty advisor is the confusion caused by the complementary EPICS class offering. The team was founded before the course section was created; any student interested in the biomedical field was invited to join BSDT. The course was subsequently created to facilitate a structured meeting time and allow the students some credit for their work. But no other such student organizations have an associated course. And though the BSDT welcomes students from all over campus, the course currently allows only engineering college students to enroll. Further, some students are enrolled in the maximum number of hours for full-time students, and are concerned that they will not be able to participate in the projects because they cannot enroll in the EPICS course. Resolving this remains a communication challenge within the team, but the reality is that only half of the BSDT participants are enrolled in the course.

Another frustration was the unfortunate timing of the COVID pandemic, forcing all students off campus during the spring of the group's first year, just as the project construction was in full swing. The pandemic also created staffing and other difficulties for the Hardin County Board of Developmental Disabilities, the BSDT client for these initial projects, adding months of delay to the client feedback on the various projects.

On the positive side, the team advisor cites the number of different simultaneous projects as a definite advantage. All students have the opportunity to get involved in a project in which they are interested. First- and second year students can meaningfully participate right away, rather than being mere observers as they might be in some other organizations. Sustaining multiple projects, however, does make it harder to keep track of the progress of each individual project.

Conclusion

The creation of the Biomedical Sciences Design Team has been a great addition to the array of student organizations in the ONU College of Engineering. Students have employed their design skills and growing engineering knowledge to create practical solutions to improve the lives of disabled students and their teachers, and are now reaching out with projects serving a broader spectrum within the community. They get experience working with students in different specialties, learning to take full advantage of one another's skills, contacts, and different perspectives.

Having a complementary 1-hour EPICS course to provide dedicated time and structure to the team can be an asset. But the course also causes communication challenges and potential perceptions of inequity between BSDT members who are and are not part of the course.

BSDT students employ the full range of the design process, from problem framing and ideation to prototype, testing, and delivery. They begin by exercising empathy, working to fully understand the experience of their client through observation, interaction, and immersion. Such an exercise is difficult to replicate in the traditional engineering classroom. Students gain confidence from the success of their completed projects, benefit from the interaction with real world clients, and deepen their appreciation for the satisfaction that comes from using one's time and abilities to serve others.

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