



## Occupational Therapy Boards – Identifying the Value of a High-Impact Service-Learning Project

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## **Identifying the Value of a High-Impact Service-Learning Project**

### Abstract

Developing students' appreciation for the societal benefits of engineering is one of the key tenets of EPICS (Engineering Projects In Community Service), a service-learning program. In achieving this goal, it is important that students see the direct application of the knowledge and skills they have acquired as engineering students. When students are able to engage in a full start-to-finish design process within a team and, importantly, along with a genuine client, they have greater potential to appreciate the social responsibility aspect of professional engineering.

A unique EPICS experience is under development that aligns with these guidelines, focused on the creation of "occupational therapy boards," designed to improve the fine motor skills of children. Borne out of an idea to develop engineering students' design thinking and fabrication skills, this project provides a construct for engineers-in-training at all levels, and can be molded to best suit the students' skillsets and/or project partners' desires.

In the EPICS project under review, undergraduate engineering students have had the opportunity to work with occupational therapists at both a pediatric rehabilitation clinic and a local preschool. This research study identifies potential benefits, limitations, and recommendations so that the project can be more easily adapted by other institutions seeking high-impact, low barrier-to-entry experiential learning opportunities.

### Project Background

As part of the EPICS (Engineering Projects In Community Service) coursework offered at Ohio Northern University, a new project has been developed that focuses on the design and fabrication of "occupational therapy boards." These boards, created for organizations serving children with physical disabilities, are roughly 2'-by'-3' in surface area, include a self-standing mechanism, and feature manipulative elements to promote fine motor skill development. The impetus for this service-learning project came from a desire to offer undergraduate engineering students an authentic opportunity to further develop their fabrication skills, resulting in finished products that would directly impact the community and foster students' appreciation for the relationship between engineering and social responsibility.

Fostering students' "Base Skills," a facet of the professional development realm related to socially responsible engineering, as defined by Canney and Bielefeldt,<sup>1</sup> aligns with the project's connection between technical abilities and resultant societal benefits. This connection is viewed as imperative for developing future engineers' attitudes towards human-centered design and their roles in society.<sup>2,3</sup> Similarly, ABET calls for holistic skillsets that encompass both technical skills and "an understanding of professional and ethical responsibility," while the National Academy of Engineering has emphasized the importance of interaction with community partners and service-learning.<sup>4,5</sup>

The following areas were established as key learning outcomes for the occupational board project: 1) design thinking; 2) fabrication, including competency with a CNC router, laser cutter, soldering iron, 3D printer, 2D and 3D modeling software, and traditional woodshop tools; 3) project management, including competencies in scheduling and budgeting; 4) communication, through interactions with peers and clients (when seeking feedback) and college faculty and staff (when seeking technical support); and 5) creativity.

The purpose of this investigation is to identify the value of this novel project and to offer recommendations so that it can be easily adapted by others seeking high-impact, low barrier-to-entry experiential opportunities.

### Project Logistics

This study encompasses two courses of the therapy board EPICS project, offered in the Spring and Fall 2017 semesters, during which three undergraduate engineering students participated each semester (two students participated in the course both semesters; a total of four unique students). During the initial offering, occupational therapists at a pediatric rehabilitation clinic served as the project partner; the following semester, occupational therapists at a preschool served as the partner.

The instructor's role for this one credit hour course consisted primarily of guiding students through the engineering design process; this included leading activities to elicit novel ideas, facilitating discussions to promote peer feedback, and steering individuals towards product features that would best serve the end users and could be reasonably completed under the time and budgetary constraints. Project management documents, such as meeting minutes and a schedule with clear progress milestones, were also required to better formalize the process and expectations.

The group met once each week. During the initial stages of the project, the students engaged in lengthy deliberations about the merits of various design ideas, and after speaking with the project partners, agreed upon the features that aligned with the partners' requests. Six weeks into the semester, the meetings served as check-ins to report on the project progress and communicate any challenges related to material procurement or component fabrication. The students were expected to take responsibility for seeing their designs to fruition; this student-led learning environment allowed individuals to pursue their own interests, helping to foster in particular "a recognition of the need for, and an ability to engage in life-long learning," a key ABET learning outcome.<sup>4</sup>

### Project Outcomes

During the initial course, students were responsible for creating their own therapy boards. Few constraints were placed on the project, and among the three boards produced, students fabricated the board stands along with two to three of the features, with the remaining items being off-the-shelf products. In Figure 1, for example, a student laser engraved and hand painted two book-like features that could be opened to reveal animals, as well as a knob that could be guided through a curved slot in the board. All other features (e.g., doorstops, bells, and a latch) required less

customized work. Figure 2 shows another student's work. Again, most parts were off the shelf, though the student did produce a clock from 3D printed parts and animal shapes using a CNC router. It is important to note that this original project was coupled with a second project modeled after The Ohio State University's Toy Adaption Program, which aims to modify electronic toys for use by those with physical limitations.<sup>6</sup> Thus, there was limited time to produce truly custom products.



Figures 1 & 2: Example therapy boards from Spring 2017

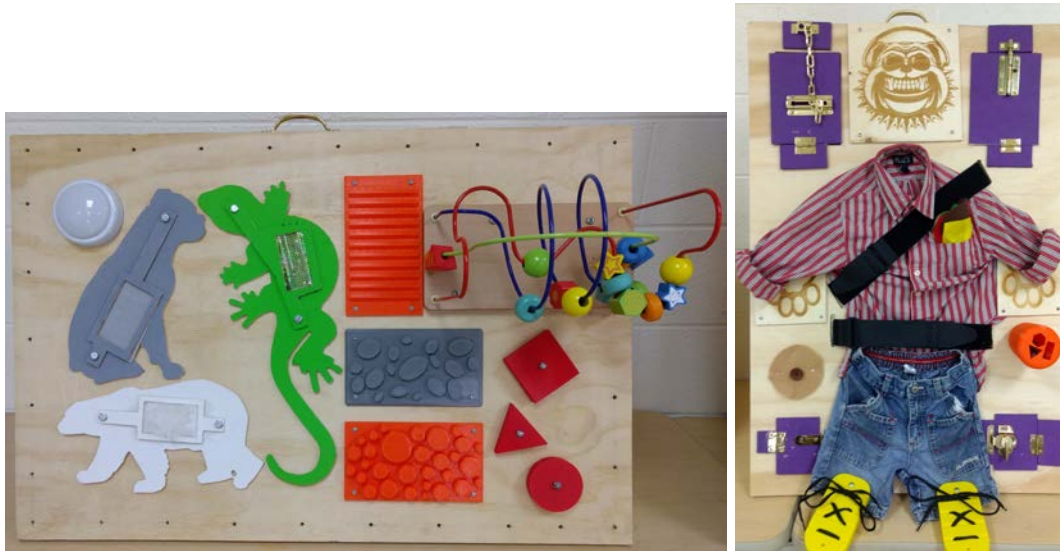
During the second offering in Fall 2017, students were no longer permitted to simply attach ready-made products. This constraint was implemented for a number of reasons: 1) in the previous semester, students had been overly reliant on simply purchasing finished products and affixing them to their boards, limiting their potential to create designs that best met the project partner's needs; 2) a custom approach required a greater attention to detail and understanding of component assembly; and 3) students in the college had largely reported a desire to improve their fabrication skills, but opportunities to do so as part of a course were scarce.

All parts were therefore required to be student-fabricated/modified, governed by a number of artificial project constraints. For example, students were expected to create at least one original part using a 3D printer and one part using a laser cutter, and were encouraged to incorporate electronics and the use of a CNC router. In addition, the project partner (with some prodding from the author in order to elicit a more specialized design), requested boards with specific color schemes and functions. In particular, they requested three boards in total, each focusing on a different developmental area: sensory (promoted via various surface types), ADL (activities of daily living; e.g., using zippers and buttons), and prehension (e.g., grasping and pinching).

Rather than create their own boards, the students elected to work on the boards together. This was partly in response to their more isolated experiences the previous semester, and the students' belief that through collaboration, they would be able to generate more creative designs and utilize one another's skillsets to construct higher quality products. Unfortunately, due to the added layer of organizational complexity and newly imposed fabrication constraints, the group

was only able to complete two boards by the end of the semester (both of which required extensive reworking the following semester, including the replacement of some lower quality student-created components with more robust, purchased items).

The final products are shown below. Figure 3 contains various surface types, including animal shapes created with a CNC router (each of which includes a sensory pad related to the animal's texture) and 3D printed plates and rotating shapes. Figure 4 included a number of ADL features that required users to buckle, open, tie, insert, button, zip, and latch.



Figures 3 and 4: Example therapy boards from Fall 2017

## Research Methodology

Data for this investigation was collected from students' self-assessments, written reflections, and post-course interviews (audio recorded and transcribed). These interviews were semi-structured in nature, following a general outline of questions related to the project's learning outcomes, format, instructor's role, and social responsibility; the students were encouraged to provide input on any topics they found to be most pertinent to the project.

Due to a desire to evaluate the value inherent in the project from the students' perspectives, no interventions or otherwise targeted discussions took place before or during the course that may have externally initiated students' consideration of the project's merits with respect to broader topics such as creativity, transferrable knowledge/skills, and social impact. In other words, no direct attempts were made to tie the project activities to more overarching benefits, but, rather, students were left to identify these connections on their own (e.g., students were not asked about "social responsibility" until after the course).

Because the study was exploratory in nature, the collected data was qualitative, allowing for students to express their ideas with little bias created by the feedback instruments themselves. This student input was evaluated using qualitative analysis methods, including using descriptive codes to identify data, lumping discrete data into similar themes, quantifying which topics were most frequently raised (both in terms of the number of individuals as well as the number of times

each individual raised a particular topic), and identifying commonalities and discrepancies among the participants.<sup>7,8</sup> Selected quotes in the following sections are intended to represent views of the consensus in many cases, but also give voice to individuals with conflicting perspectives; in either case, the narrative is designed to provide insights into the participants' experiences, thereby providing tangible justifications for the project's merit. Note that these results, due to the small sample size ( $n = 4$ ), are preliminary in nature and may differ from a similar project conducted with a larger number of students.

The study was carried out with the following exploratory research questions in mind:

1. How does the project experience complement the knowledge and skills learned in traditional engineering education?
2. How does the project experience influence students' perspectives of the relationship between engineering and social responsibility?

### Perceived Value

“Just working with an actual client, I've never done that before. So that's kind of insight into the engineering world, meeting with that client, figuring out what they want, and then replicating it.”

When considering the project's value, the most frequently raised topic was their interactions with the client, discussed by all students multiple times. This was extremely surprising since, in relation to the other project activities, the time spent interacting with the occupational therapists was negligible. During the first course, the students spoke to an occupational therapist at the rehab clinic once at the beginning of the semester, followed up with three brief emails to gather feedback on design ideas, and visited her at the clinic for about 20 minutes. In the second course, the students had an in-person meeting with two occupational therapists and a vice principal at the school, followed by three brief emails.

However, from the students' perspective, knowing that their final products would be delivered to a genuine customer presented a more authentic experience, as evidenced by a student who stated, “I think that's really important to get to meet your client and get to get a feel for what's really important for them. Some might say that's really important in an email, but you don't get that vocal inflection when they say it...” Likewise, direct input from a working professional made a strong impact on the students, as demonstrated by the individual who noted, “I think that made a world of difference to get their feedback. Because otherwise you're just designing blind and you hope they like it.”

Even though the feedback offered by one of the occupational therapists was very limited (one student complained that the therapist only replied with “that looks nice” when asked about various design features), the students still held the value of these interactions in high regard, and gave them insight into the reality of client relations. One student pointed out, “I think it was valuable even though they didn't communicate back and forth because it kind of showed that sometimes you have to work with what you have.”

Two students explicitly suggested that the therapists provided additional motivation for creating a successful product, as compared to working for a hypothetical client (i.e., a professor), such as

the student who noted, “It’s just a different mindset when you’re working with an actual client.” Yet another student, who clearly found merit in working with external partners, also found their involvement unnecessary in some regards, noting that because she had taken the course once before (albeit with a different project partner), presumed that she had enough experience to “have an idea of what a typical client would want,” thereby discounting the fact that different therapists with different patients might desire different designs. It is important to note that her comments were borne out desire for a more open-ended project and a sense of frustration with the therapist’s requests, which she viewed as overly constraining.

Students also commonly indicated that their fabrication skills improved as a result of the course, noting greater proficiency with tools such as a 3D printer, laser cutter, CNC router, soldering iron, and SolidWorks. Interestingly, although enhanced fabrication skills was a key learning objective, no students indicated that this was a primary reason to enroll in the course, nor did they view fabrication skills as directly benefitting them in either college coursework or in the engineering profession. Although they believed the construction experience might help with a senior capstone project, they saw fabrication as disparate from engineering practice, which they viewed as heavily focused on theory and application. Rather, they believed the soft skills embedded in the project – such as time management, scheduling, and communication – were the key takeaways for developing as professional engineers.

#### Effect on Social Responsibility Outlook

Interviewer: “Define social responsibility as it relates to the engineering profession.”

Student: “I think you have the responsibility to your client to deliver a quality product, and social responsibility, I don’t like the word “social” in front of that, so I don’t know how to answer that.” [Laughs]

If the participants did not enroll to gain experience with fabrication tools, what did motivate them to enroll? Put succinctly – helping others. All students spoke in depth of possessing an innate desire to assisting the disadvantaged, citing past service projects in high school, having family members with disabilities, and wanting to provide value to the community. Notably, although these students were predisposed to serving others, they either failed to mention any connection between engineering and positively impacting society, or explicitly noted a disconnection between the two, such as the student who stated, “I think that’s really hard sometimes as an engineer, to do some social good and give back to the community.”

Instead, the students generally saw the social responsibility of an engineer as the devotion to successfully and ethically meeting a client’s needs; in other words, they believed social responsibility to be synonymous with an “obligation” to a customer, as opposed to a proactive effort to improve society. This perception of social responsibility can be illustrated by one student’s reflection: “I hadn’t really thought of social responsibility when we were doing the project, I just wanted to fulfill the client’s needs and make the best product that I could. Which now that I think about social responsibility now, that’s how I would define it, with the moral aspects.”

No participants noted any change in their understanding of social responsibility after their experience with this service project. They believed they already had a clear sense of a professional engineer's ethical and moral duties, and somewhat peripheral to this belief, they did not feel that the project further motivated them to help others. They attributed this lack of enhanced motivation to their giving dispositions prior to the course (akin to "preaching to the choir"). However, the students did believe that their engineering college peers, particularly those without previous service project experience, could benefit from the course by developing a greater appreciation for helping others (though again, their discussions lacked any realization of connections between the engineering profession and societal benefits).

While the participants generally believed that including a service learning project as part of an engineering degree requirement was not necessary (one noting that such a requirement would lead to student push-back), all participants readily agreed that social responsibility (as per their somewhat misaligned definition) should be interwoven throughout the engineering curricula so that students would have a greater appreciation for the expected ethical standards of engineers. Thus, the idea of making social responsibility very explicit in a course's learning objectives and touching on the topic throughout a semester was strongly recommended. Even in service learning projects designed to directly impact those less fortunate, where the societal value of engineering is inherent in the core of the course, taking class time to directly address and discuss the topic was encouraged. This point is evidenced by one student's suggestion: "Maybe you could pose that question, what is social responsibility, because I honestly hadn't thought about social responsibility in relation to the EPICS course before you just asked us."

### Recommended Logistics

"The project was rushed in the end and maybe needed more of a guiding hand from the instructor when it became clearer that certain aspects of the project were being put off and the instructor could have brought the group more on task."

Although generally pleased with their EPICS experiences, the students offered a plethora of ideas to improve facilitation of the course. They saw project as clearly student-centered, though one in which the instructor needed to provide adequate guidance since projects fell behind schedule both semesters. One student suggested that an instructor needs to "make sure we're keeping on top of getting pieces done" while another admitted that "we did a whole lot of talking, but not a whole lot of following through with things that we talked about in class."

This is not to say the students did not devote significant periods of time to the course (one student mentioned that he worked for 13 hours one week just on soldering), but their design plans were ambitious and other coursework and obligations were prioritized until they realized they were significantly behind schedule.

It was strongly suggested that the instructor play a larger role in teaching specific workshops related to fabrication tools (rather than permitting the students to explore these on their own). Lessons devoted to project management were also viewed as worthwhile inclusions, particularly related to creating Gantt charts, budgets, and Excel in general, as they believed doing so would have allowed them to better conceptualize their ideas and establish more appropriate plans for



the semester. These one-hour workshops/lessons were recommended for the initial weeks of the semester only, replaced by weekly “progress check-in” meetings once product designs were established.

Other recommendations for the course format are summarized in Table 1.

Table 1: Summary of course recommendations

Topic	Recommendation	Notes
Fabrication tools	Provide list of available tools – require students to choose 2 to 3	One student recommended setting more specific guidelines to prevent choosing strengths: “I wouldn’t necessarily try to branch out and try to learn new things because I’d focus on what I already know I’m good at.”
Teams	2 to 4 students per board	Creating multiple boards in one group proved logistically challenging
Cost	\$50 to \$75 per board	Does not include costs of wood or 3D printer filament; lower costs viewed as sacrificing quality
Credit hours	2 to 3	Viewed as too much work for 1 credit hour course
Participants	All university students	Inviting non-engineering students seen as greatly beneficial, particularly those from technology, arts, and education
Schedule	3 one-hour time blocks in dedicated workspace	Meet for 1 hour, fabricate for 2; scheduling group work times viewed as difficult challenge to overcome

A key point of disagreement was related to the class levels for which the project should be offered. While all of the participants felt the project was appropriate for sophomores, juniors, and seniors, three participants did not believe that freshmen would possess enough maturity, dedication, and skill to complete quality products. However, a lone participant recommended that the project be utilized as part of the college’s first-year course sequence (the college requires first-year students to take two introductory engineering courses), and indicated that many of the learning objectives for freshmen are already embedded in the EPICS project. In fact, the five aforementioned EPICS course learning objectives (related to design thinking, fabrication, project management, communication, and creativity), which were demonstrated throughout the projects (albeit, could be improved with additional guidance and structure), align well with the common first-year courses. Additionally, first-year students are expected to begin developing a “professional mindset,” and an authentic service-learning project can help promote this idea.

## Conclusion

The EPICS course detailed in this investigation was initiated for students to engage in a service-learning design project with little pre-requisite experience. While gains were realized in students’ fabrication skills as expected, participants indicated that this learning objective was neither a driving factor in their decision to enroll in the course, nor was it viewed as strongly connected to engineering in general. Instead, a desire to help others provided the initial motivation, while project management and communication skill development – most notably during client

interactions – were noted as the primary professionally relevant activities. Referring back to the study’s two research questions, it is apparent that, from the students’ experiences, there is a disjointedness between both fabrication and social responsibility with respect to professional engineering.

Interestingly, other than a single participant who made three passing remarks about design (e.g., “I have gained knowledge and increased my abilities in soldering, planning, and design.”), no mention was made of either design thinking or creativity, two significant learning objectives that were listed in the syllabus and implicitly included in the course activities. Analogous to a similar dearth of appreciation for the intended connection to social responsibility, the importance of design and creativity in the project was not realized as expected. Therefore, it is strongly recommended that similar projects explicitly address these fundamental concepts regularly throughout the semester, drawing connections between design, creativity/innovation, and social responsibility to both the project and engineering in general. For example, an instructor could provide prompts related to social responsibility for discussions and/or written reflections, thereby continuously tying classroom activities to opportunities and decisions students may encounter as future professional engineers.

The therapy board project shows promise to be a continuously supported EPICS project. Students are able to develop fabrication skills, obtain experience with project management basics, and work with real clients. From a pragmatic standpoint, the project can be completed in just one semester (most EPICS projects are two semesters at ONU) and each product can be created for less than \$100. The cross-disciplinary nature of the project also shows potential for fostering interactions among not only engineering students from different departments, but among students from different colleges, an essential component of a non-siloed, more comprehensive education.

Challenges do exist for successfully carrying out the project, however. As with many student-centered environments, the degree to which learning takes place is highly dependent upon individuals’ motivations. Although all participants noted that they were determined from the outset to dedicate serious effort to the project, the self-paced and open-ended nature of the course, while appreciated by the students, at times allowed them to delay their involvement in lieu of their core coursework. To support a stronger project, students suggested that they earn more credits and be held to a tighter schedule by the instructor, as they found themselves postponing project milestones too easily.

A second key challenge is continuously identifying project partners. Since the number of entities serving children with physical disabilities is somewhat limited, a more productive route may be providing the therapy tools directly to children to use at home. This could be supported by using current project partners as a conduit for delivering the products, but establishing this type of network on a semester-by-semester basis is certainly a non-trivial matter that can quickly consume an instructor’s time.

Future work in this area will include piloting the project in a first-year, three-credit-hour introductory engineering course, whereby the instructor will have an enhanced ability to manage the product development stages (in progress Spring 2018). And, due to the unexpected viewpoint

that fabrication has little importance in the development of an engineer's mindset, this study has also spurred interest in investigating the question "What is the value of hands-on work in professional engineering?" This is particularly significant since many K-12 engineering curricula are designed around hands-on activities and project-based learning; having engineering undergraduates report that this connection is not important indicates a misalignment between pre-engineering and college-level coursework.

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