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Engagement in Practice: Lessons Learned and Outcomes from the Creation of an Engineering for Sustainable Development Makerspace to Support Collaborations Investigating Passive Gravity Water Treatment Plants

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Background

The mission of the Humanitarian Engineering (HE) Program at The Ohio State University (OSU) as stated within the program mission document is to, "educate students on the application of science and engineering to address complex societal challenges with an emphasis on collaborating with communities to achieve their desired vision of well-being through a curriculum grounded in proven theories of sustainable development and applied engineering and socio-cultural learning experiences."

This mission and resultant student learning outcomes were created with the intention of training students with the skill sets required to address complex societal challenges built from the experiences working within the Engineering for Sustainable Development (ESD) realm.

The ideals that have emerged from this domain focus on considering political dimensions, structural conditions, ethical considerations, as well as stakeholder understanding, values and dynamics; these considerations are aimed at addressing the problematic engagements and pitfalls seen historically within the HE domain. "Humanitarian Engineering" effectively and cohesively integrates these skill sets and linkages to address issues far beyond what we have historically and ethnocentrically determined as an "engineering".

Developing Collaborative Partnerships

An increasingly interconnected global economy demands collaborative opportunities and presents unique challenges, compounding the need for broadly educated engineers that are well-versed in intercultural competency. OSU's Humanitarian Engineering program equips graduates to meet these challenges through community-engaged learning and high impact educational experiences.

In preparation for equity-minded and ethical collaborative engagements, the partnership structure and relationships have been carefully and thoughtfully established over multiple years in response to past project and partnership challenges. At times, well-intentioned university-forged relationships with partner communities and resultant projects have elevated the applied student experience to the neglect, or even detriment, of the served communities [1]. Projects of this type can unintentionally become transactional in nature [2] by ignoring social injustices, reinforcing deficiency-based community development ideals, and serving the academic calendar and students more than communities [3][4].

In the simplified academic version of the design process, it is difficult to convey to students the complex context of stakeholder values and to incorporate social dynamics [5]. Student proposed solutions tend to focus on purely technical aspects and struggle to integrate the complex contextual elements [6]. Our model of engagement focuses on aligning values across

collaborations by prioritizing relationship and capacity building with partners and shifting away from “tech to the rescue” style projects.

Engineering for Change (E4C)

A collaborative partnership has been ongoing between OSU and Engineering for Change (ASME). This research collaboration explored existing lab spaces across the Engineering for Sustainable Development domain to compile lessons learned and best practices. The final report concluded that curriculum intersection, multi-functionality, strong internal and external partners and a core group of faculty leading the effort was critical to the success of other spaces.

AguaClara Partnership

The backbone of the HE Lab is the partnership with AguaClara Reach to address global water access and quality challenges. The purpose of this collaboration is the development and dissemination of tailored low carbon footprint water treatment plants to further global access to safe drinking water using gravity-powered technology. The AguaClara Reach partnership leverages projects across undergraduate research, courses, and capstone. With future opportunities that will pair with community engaged learning courses providing multiple avenues of engagement across the collaboration.

Establishing the Humanitarian Engineering Lab

Need and Ideation

Over the last twenty years, the Engineering for Sustainable Development field has been growing across the academic domain. Many universities are offering programming and courses in the space. Establishing labs and programs to prepare people to contribute to Engineering for Sustainable Development is essential to grow these programs in the future. While engagement within this realm has been demonstrated to positively impact students cognitive and affective abilities, there are still limited opportunities for hands-on exploration that does not utilize partners and communities as experimental technical oriented solution testing grounds. With this shift away from technocentric implementation and restructuring partnership engagements. The program lacked on campus presence as well as the physical lab space required to experience hands-on prototyping aimed at building conceptual understanding as projects shift from ideas to realization. Thus, our goal was to create a physical space for Humanitarian Engineering projects that would serve as a community hub at OSU, as previously there was no dedicated space on campus for this purpose. Given that many of these projects were student-led and or siloed across academic units, they were relegated to off-campus apartments or alleys on campus, using whatever limited tools they could acquire. The motivation stemmed from the idea that having a communal lab space available for students and faculty to access would enable them to further their work and educational training, while building community across the various entities. Therefore, a “home” was essential for improving the operation of Humanitarian Engineering projects and establishing a presence for the work on campus was proposed. The idea to create a physical home was proposed and to gain input to the design and layout of a potential facility, a series of roundtable discussions were conducted. Participants included representatives of different units on campus that would potentially collaborate on projects utilizing the space. The

required (and desired) tools and functionalities of the space were identified. Key objectives of the proposed space were the ability to brainstorm solutions and develop prototypes.

Further, the aforementioned partnership with E4C produced a landscape analysis to support the creation of a dedicated space. Most programs that were included in that study had been able to start the lab after receiving a corporate donation, or sizable funding through a variety of ways including alumni, internal grants, and direct donation solicitation. All interviewees described filling a gap that existed at their institution because they had lacked a space or opportunity to provide students with EGD-related experiences. Communicating the value of EGD research and learning opportunities to industry partners was therefore highly recommended.

Implementation and Research Capabilities

The aspirations of the space were to:

- Provide students appropriate space, resources and tools to develop hands-on skills and act as a piloting ground for service-learning and community engaged learning projects that have a global impact focus.
- Provide students with experiential learning opportunities to develop and work directly with sustainable technologies and community development efforts.
- Support team-based, multidisciplinary, experiential learning opportunities that engage students at multiple points in their academic careers: from introductory and survey courses to capstone design and research initiatives.
- Exposing students to the skills, materials and techniques associated with the global challenges in sustainable development.
- Provide accessible meeting space for student teams to work on engineering for sustainable development initiatives, interact with internal and external partners, and support planning and design work from concept through prototype.
- Provide collaboration space to foster an inclusive environment and to build community.

A relatively small space was identified on campus (~600 sq ft.). The awarding of internal grants allowed for the space to be outfitted with work benches, whiteboards, a projector, hand tools, and other items essential for student innovation. A 3-D printer is available for modeling and prototyping.

The space is also equipped with computers and monitors for virtual meetings and has been used for calls with international partners. There are currently workstations for two different projects to be in the lab simultaneously. A simple but critical edition was a shelf and storage system for different Humanitarian Engineering centric courses, projects and organizations to store materials and use on campus. Previously, supplies had to be transported to and from campus each day by students in a student organization or stored in faculty offices.

Figure 1: Current Lab, (Left) 2022 and (Right) previous area where students worked on their projects 2018

Impact and Utilization of the Makerspace

The initial opening of the space took place during early 2021 as engagements on campus started to trend back to in-person activities. Stemming from undergraduate research project efforts and to support student organizations, the availability and functionality of the space slowly started to attract students. Having a secured and assessable location on campus to store project materials improved the feasibility and execution of their Humanitarian Engineering centric projects. Since then the lab space has become an essential part of the HE program, and is rarely unoccupied by student groups.

Lessons learned

From the humble beginnings of an abandoned cleanroom, the Humanitarian Engineering Lab has served students from across the academic landscape and provided a "home" for Humanitarian Engineering. Fortunately, this success has bred a new host of challenges. The need for expanded capacity and space is evident. The space currently supports 12 courses, three students' organizations, undergraduate and graduate research culminating to engage over 350 students.

Centralized Hub

The localized space has allowed for building of community across students, faculty and academic units. While also providing continuity of project and program efforts. The ability for student engagement has increased as with the strenuous and overcrowded academic degree requirements of engineering students, the lab space has supported a broader effort to provide students opportunities across an array of experiences, thus reducing barrier for engagement as students can partake from the student organization level, research, technical focused courses and capstone level. Tracking and highlighting the student's use and impact was critical to showcasing the need for the space to decision makers as well as justification for expansion of the space.

Showcase

The lab space has also provided an opportunity for internal and external demonstration across K-12, Alumni, Industry, campus visitors and various academic units. The physical space allows for

visitors to see and interact with the various collaborations that span global relationships.

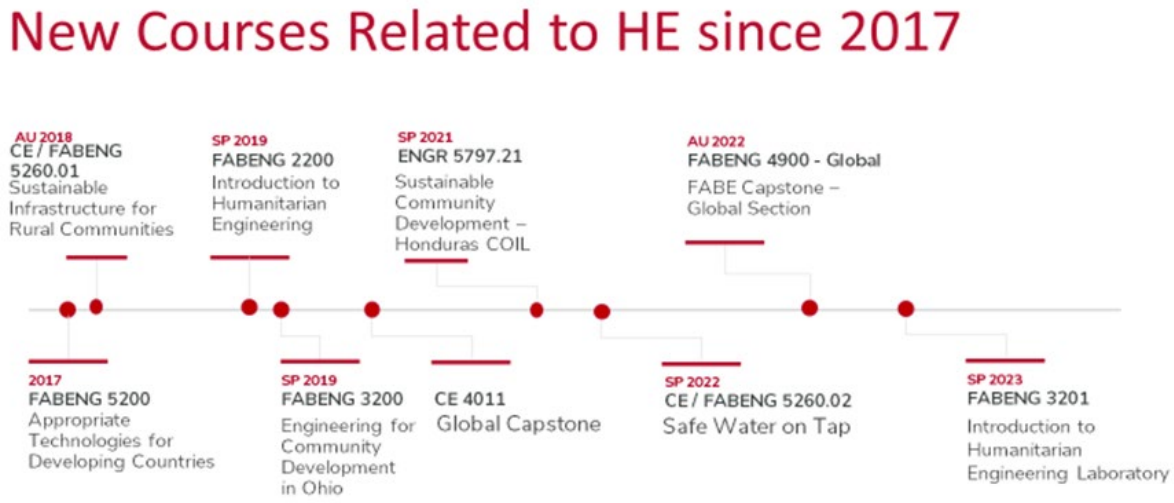

Figure 2: Courses Supported by the lab

Challenges

Space. With the immense student interest, the current space has currently been outgrown. There are consistently more students that are interested in research and independent projects than the space or faculty can manage. With the growth of the utilization of the space the logistics around scheduling and maintaining has also increased. There are two student assistants that have been hired to support the space.

Misperceptions (not study abroad). With the expansion and growth of the Engineering for Sustainable Development space, there still remains a misconception that these educational opportunities and experiences are solely study abroad. While travel abroad may be one component or opportunity, the space has demonstrated that local project and engagement efforts are a viable student growth experience.

Conclusions and next steps

Collaborations have significantly increased with academic units and, in particular, courses focused on the Humanitarian Engineering sector are now able to have a collaborative space. The Lab allows for student driven proposed solutions to be transformed from conceptual ideas to physical entities. Thus, allowing students to gain valuable insights into the viability of proposed community-based solutions. Ongoing related research efforts related to Global Sociotechnical Competency have demonstrated the positive impact of the space on students with student that utilized the space for their project efforts seeing a higher resultant score on the Intercultural Development Inventory. The facility also fosters a sharing of ideas and a collaborative spirit amongst ESD focused organizations around campus. This facility has laid the foundation as a space for student organizations, courses, and capstone projects to collaborate.

While our makerspace effectively promotes Engineering for Good for our students, we are also seeking intersections with local industries as well. For example, an expanded lab with a research emphasis in the water sector could partner with local water companies to provide access to university resources and students. We also aim to work on development problems that

immediately affect the university and local area. The physical space also makes it easier to communicate the value of these projects to potential partners. These networking opportunities also relate to our pursuit of other forms of support and funding - federal grants, university partnerships, and alumni donors. We also seek to showcase this work through community outreach, e.g., research fairs or "open house" events, where students and faculty can present.

Visibility to both internal and external stakeholders is paramount. Visitors need a facility that communicates sustainability centric technologies and showcases current and previous humanitarian engineering project work. Future plans for the space include outfitting with communication tools and media, representing external partners, models and mock-ups of the projects.

As we continue with the trajectory of building meaningful collaborative relationships across the University and external partnerships, the lab is well positioned to become a convening space and incubator for Engineering for Sustainable Development. Thus the facility will contribute to the cross-pollination of project ideas, designs and a common knowledge foundation. However, as involvement in Humanitarian Engineering programs grows, the Lab will need to adapt and have additional areas for students to learn and engage.

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