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Engagement in Practice: Better Preparing Students for Community-Engaged Engineering by Restructuring an Academic Program, Minor, and Curriculum

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Engagement in Practice: Better preparing students for community-engaged engineering by restructuring an academic program, minor and curriculum.

Background

Several universities have developed courses guided by partnerships with communities and community organizations. Students work with communities to define or implement solutions to perceived needs. These programs are often labeled service learning, community engaged learning, and/or global service learning [1]. These programs are intended to build collaborations beyond the university and motivate students by allowing them to come alongside existing community visions and actions. At the Ohio State University (OSU), a Humanitarian Engineering (HE) minor has been offered for the past decade, including many community-engaged courses. There are currently 55 students enrolled in the minor, including 56% female and 10% underrepresented minority and representing every major in the College of Engineering and four additional majors.

Students seeking the HE minor are required to participate in at least one community-engaged engineering course. Recent courses have partnered with organizations and communities in Guyana, Guatemala, Honduras, Ghana, Tanzania, and the United States. Students typically, with exceptions due to COVID-19, travel to the partner sites as part of a semester-long course to engage with community members and collaborate on the co-determined projects.

There has been an active movement towards prioritizing community impacts as equally, if not more, important than student outcomes [2]. In addition, there have been recent broader efforts to shift from "service" to "learning, partnership and community development" [3]. With our community-engaged engineering courses having been offered as stand-alone courses, several instructors were concerned with students' lack of preparedness to work with community partners and overall motivation, as well as the overall continuity among courses. Students struggled to work alongside partners to identify felt needs and design for low-resource settings in a short period of time. In many cases, the project solutions gravitated toward a technical innovation, thus subverting the relational and contextual element [4]. Students were lacking the skills required to overcome assumptions and properly consider the challenges presented by community partners within the duration of a semester [5]. This often resulted in negative to neutral results for community partners, unaware or frustrated students, and a lack of applicable solutions [6]. Thus, replicating the struggle of maintaining balance and trade-offs between the academic setting and the community of end users seen across this domain [7],[8].

Our experiences with the process of guiding students from "*technical instrumentalism*, or a stubborn focus on technical knowledge and solutions," [9] to "*contextualism*, or the understanding that solutions must consider social, technical, and environmental contexts" [9], prompted the restructuring of partner projects and the HE program. Project timelines were elongated to span multiple years with continued partnership engagement. That builds and resonates with efforts and practices aimed at creating and maintaining ethical partnerships [10].

A further motivation to restructure the HE program was the goal of scaffolding the educational experience so that students can learn principles of community engaged engineering, then engage

with a community partner, and culminate their academic experience with a year-long design course in partnership with the same community. The goal was to create a clearer pathway to obtaining the HE minor for students, thus increasing accessibility for students while also resulting in better outcomes for community partners. This paper discusses the process of restructuring the HE program to better prepare students for the complexities of community-engaged work.

Project Design and Execution: Aligning, Restructuring, Adding

Faculty and staff across multiple departments and programs engaged with HE at the university gathered to address the preparedness of HE students and graduates. Beyond better outcomes for undergraduate students and current community partners, members were motivated by a desire to build a cohesive HE program and, eventually, a graduate program. There was ample discussion regarding the name Humanitarian Engineering and its connotations, definitions, and implications, but it was ultimately decided to move forward without changing the program name due to a number of factors, including the number of potential names already used to refer to other programs within the large university ecosystem (global engineering, engineering for community service, sustainable and resilient communities, etc.). We began by finding alignment on the programs mission, vision, and student outcomes. This was accompanied by a restructuring of the HE minor (Table 1) to provide scaffolded learning experiences and the addition of an Introduction to Humanitarian Engineering course.

Aligning on Student Learning Outcomes

Design

The initial step towards providing the structure for students to gain relevant community-engagement skills and knowledge was to reassess the learning objectives of the HE minor. To this end, several faculty, staff and students gathered three times in the 2017 spring and summer semesters. Several of these members participated in the Humanitarian Engineering Advisory Council, a voluntary committee of faculty and staff dedicated to the HE minor curriculum. The process began with brainstorming a list of learning outcomes for the students. Additional faculty and staff added learning outcomes they felt were pertinent to the list. The final list of 29 learning objectives was then coded by all faculty teaching courses within the HE minor to see whether or not their class addressed each learning outcome at the advanced, intermediate, and beginner level, from their perspective. The learning outcomes that were either weakly or not at all covered in the existing coursework , alongside the previous observations of lack of community-engagement skills, guided the restructuring of the minor, expansion of the HE program, and content for a new Introduction to Humanitarian Engineering course. A lack of domestic HE coursework, discovered through this process, resulted in the creation of a local community-engaged engineering course working with a partner in the city where OSU is located.

With the two new courses in place and partnerships shifting, the HE advisory council revisited the list of learning outcomes in 2021 to provide a more succinct and formalized list of mission, vision, and student outcomes. The highly subjective approach of individual faculty noting how well they felt their course met each outcome was replaced with a new process. The course

learning outcomes were acquired from syllabi for each existing HE course (some new since the 2017 review). Two members of the HE Advisory Council mapped these learning outcomes, their respective Bloom's taxonomy level, and their alignment with the newly drafted HE student outcomes. This both helped shape the student outcomes and helped to understand the current strength of the program in providing graduates with the intended abilities.

One risk of having existing HE faculty and staff draft the mission, vision, and student outcomes for the program is the historic lack of community-engagement skills in engineering curricula. Thus, many of the faculty and staff within the HE advisory committee (though not all) have academic backgrounds in engineering but are not formally educated in community development. Therefore, much of their perspective on the desired learning outcomes is informed by personal experience in the HE space, rather than an understanding of the literature and best practices. To overcome this limitation, several steps were taken throughout the 2017-2022 timeframe. An undergraduate student was hired to find and review college and university community-engaged engineering curricula (under a variety of names), with the goal of incorporating additional components the team had not defined and/or finding congruence with other programs. The faculty and staff at OSU also continued to educate themselves through reading relevant literature and engaging in professional development. Some examples include attending the ASEE Community-Engagement sessions, the KEEN Service Learning in STEM workshop, the Colorado WASH conference, and E4C Engineering for Sustainable Development Summit. Additionally, approaches to and impacts of community-engaged engineering courses have and continue to serve as the basis for several graduate students' research.

The draft mission, vision, and student outcome documents were reviewed by additional faculty, staff, and current and former students at OSU and external collaborators within the HE landscape for content and language. Feedback was incorporated into the final draft, with the objective of instilling graduates with skills relevant to the field of HE, in line with ABET outcomes, and aligned with professionals and peer institutions.

Execution

The HE visioning document created by faculty, staff, students, and professionals in the field now guides the development of HE programming at OSU.

Restructuring the Minor and Program

Design

The resultant learning outcomes served as the basis for collaboratively identifying the mission, vision, and student outcomes that would guide the restructuring of the HE minor. The minor was restructured to include a common core introductory course. The inclusion of a community-engaged capstone design course as the final component ensured that students would have two community-engaged experiences throughout their minor curriculum. Students can pick from several pre-existing HE courses to complete the minor coursework requirements. This creates a more scaffolded structure for students entering the HE space. Students can take the introductory course to gain theoretical skills, empathy, and frameworks. The skills acquired from the

introductory course prepared students for projects with long-term partner organizations in the U.S., Honduras, Tanzania, Guatemala, Guyana, and Ghana. This is supplemented by courses covering content in human centered design, technology applications for low-resource settings, sustainable infrastructure courses, and global phenomena. Global Capstone allows students to then engage in a year-long design project with targeted scopes within larger community partner co defined projects. Some students can build on their semester-long, community-engaged practice course projects and carry these through the Capstone course-offering partners a student team with 1.5+ years of contextualization on the specific defined problem.

Execution

Table 1. New Humanitarian Engineering Minor Requirements Starting Autumn 2022.

Required Curriculum Components	Number of Courses	Description
Introduction to Humanitarian Engineering	1 (Lecture and Lab)	Required introductory course covering general skills and knowledge for HE
Humanitarian Engineering Core Course elective	1	One of several courses focused on topics such as human centered design, entrepreneurship, or infrastructure.
Global Perspectives Course	1	One of several courses covering issues such as social justice and/or global phenomena
Community Based Learning Experience	1	One project-based course collaborating with a community partner
Culminating Humanitarian Engineering Project Work	1-2 (typically filled with two-semester Capstone Design course)	One project-based experience (course, independent research or project), at the capstone level collaborating with a community partner.

The new minor format (Table 1) applies to students joining the minor in AU22 and later. The current Introduction to HE students and Global Capstone students utilized the Intercultural Development Inventory (IDI) [11] with long-term goals of longitudinal investigation of learning outcomes and as a structure to develop intercultural competency throughout their academic courses offering within the new minor.

Adding an Introduction to Humanitarian Engineering Course

Design

An introductory Humanitarian Engineering course was developed and incorporated into the minor. This course focuses on contextualizing skills [9], empathy building, and fostering student self-awareness regarding their positionality in colonial contexts and power dynamics as it relates to community-engaged design work [12], [13].

The initial course covered content on the United Nation's Sustainable Development Goals, global lifestyles and assumption making, global natural resource and technology distributions,

colonization, valuing ways of knowing, traditional ecological knowledge, participatory development practices, career paths in HE, social impact companies, supply chain considerations, reflection techniques, and several case studies. Students also reviewed instructor-selected, current, peer-reviewed research articles in these spaces and co-presented a summary and critical review to their peers. The lab course includes exercises related to food, agriculture, water, shelter, play, hygiene, sanitation, health, energy, interviewing, and ethics.

Execution

The course was restructured throughout 2022 and is running in its new format in Spring 2023. The course was adapted to be interdisciplinary team-taught, to have a Sustainability Theme focus in line with OSU's new general education structure, and was expanded in credit hours (from 2 to 3 credit hours). This has allowed for the addition of content focused on: Stakeholder dynamics, Wicked Problems, ecology, resource decoupling from economic growth, human centered design [14], the history of the UN and Sustainable Development Goals, the overlap of civil and bioengineering applications to HE projects, and student self-awareness.

A Humanitarian Engineering makerspace has also been developed at OSU over the past four years and serves as the site of the SP23 Introduction to Humanitarian Engineering lab course. This allows for more hands-on experience for the students and access to equipment and experimental designs used for undergraduate research.

Transferrable Lessons Learned

Transferable learnings from this experience are how to a) collectively identify the vision and student outcomes for a program that spans departments and institutions and b) structure a scaffolded minor program to support student development as community-engaged practitioners.

The student outcome identification process could be more effective by using the secondary process. The existing learning objectives in all courses that are offered and being considered for a minor or major program should be mapped into generalized categories and by what level of Bloom's taxonomy they address. This helps see what skills the university is already teaching and can serve as a basis for conversations about whether additional competencies need to be added. Discussing or allowing open commentary by all related faculty and staff allows a consensus to build. Requesting feedback from professionals and other academics in the space can help maintain alignment across institutions and ensure the most up-to-date approaches and terminology are being communicated to students. This document can also help identify gaps and guide the use of resources for developing new research, partnerships, courses, etc.

The structure and form of the program can then be addressed to best meet the stated mission, values, and outcomes. Creating a structure where students all take the same introductory course, have the opportunity to choose from a variety of courses and community-engaged experiences, and finally complete a year-long community engaged project allows students to build skills through a supportive curriculum. These opportunities are supplemented with several student organizations and a recently-developed applied research laboratory at the university.

Planned Next Steps

Continuing to work with academic advisors across the college of engineering on approving community-engaged courses as technical electives and capstone design courses is important for improving access to the HE program. Using the IDI as an assessment tool may help to provide insight into the impacts of the program related to intercultural competency growth. Further qualitative assessment metrics are in development and planned for implementation.

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