Engagement in Practice: Building Community Engagement into a First-year Design-Build-Test Course

Dr. Katie Snyder, University of Michigan

Dr. Snyder is a lecturer for the Program in Technical Communication at the University of Michigan. She teaches design, ethics, and technical communication as social justice to students in the College of Engineering.

Prof. Aditi Verma, University of Michigan

Aditi Verma (she/her) is an Assistant Professor in the Department of Nuclear Engineering and Radiological Sciences at the University of Michigan. Aditi is broadly interested in how fission and fusion technologies specifically and energy systems broadly—and their institutional infrastructures—can be designed in more creative, participatory, and equitable ways. To this end, her research group at the University of Michigan works towards developing a more fundamental understanding of the early stages of the design process to improve design practice and pedagogy, and also improve the tools with which designers of complex sociotechnical systems work. She was previously a Stanton Nuclear Security Postdoctoral Fellow at the Harvard Kennedy School's Belfer Center for Science and International Affairs. Prior to her appointment at the Belfer Center, Aditi worked at the OECD Nuclear Energy Agency, her work, endorsed and funded by policymakers from the NEA member countries, focused on bringing epistemologies from the humanities and social sciences to academic and practitioner nuclear engineering, thus broadening their epistemic core. At the NEA, Aditi also led the establishment of the Global Forum on Nuclear Education, Science, Technology, and Policy. Aditi holds undergraduate and doctoral degrees in Nuclear Science and Engineering from MIT. Her work, authored for academic as well as policymaking audiences, has been published in Nuclear Engineering and Design, Nature, Nuclear Technology, Design Studies, Journal of Mechanical Design, Issues in Science and Technology, Bulletin of the Atomic Scientists, and Inkstick. Aditi enjoys hiking with her dog, reading speculative fiction, and experimenting in the kitchen.

[Engagement in Practice]
People-first engineering: building community engagement into a first-year design-build-test course

Engineers design technologies for people and communities, but the history of community engagement in the design process is limited. Reasons for this lack of engagement are many, ranging from logistical challenges (how do we gather feedback and from whom?) to cultural assumptions about knowledge and expertise [1]. Digital communication has eased the former, but we have yet to make significant progress on the latter. Abundant research suggests that bringing communities into the design process may result in products and processes much better suited to communities' needs and may protect local cultures and natural environments [2]. These positive results are tied to individuals' lived experiences; people and communities have valuable expertise about what it is like to live in their part of the world. They may have expertise in how to engage with the land, weather, culture, politics, and the built environment grown up around them.

In most cases, engineers treat community knowledge as external to the design process. But when communities are left out, technologies are often designed in ways that do not account for peoples' needs, values, or culture. Thus, the resulting technologies may amount to a waste of resources – they may even complicate the problem they were trying to solve. Worse, non-community-centered design can build in or retrench systems of inequity or bring long-lasting environmental damage [2].

For better or worse, engineering work is world-building. At this point, we need to be more deliberate, equitable, and just in the worlds we want to build. Given the pressing challenges we face as a global community, designers can no longer sideline community members' input. We must collaborate with individuals and communities to build just, equitable, and user-centered technologies to find lasting, sustainable solutions.

Course Overview

Therefore, this project seeks to bring community members into a first-year engineering course to establish community engagement as a best practice in engineering design. This course is required of all first-year engineering students at the university, and it uses a design-build-test framework. All sections feature two weekly Lectures, one 2-hour Lab, and one 1-hour Discussion. In most sections, students work to build products or processes as they learn key concepts about a specific engineering discipline (an electrical engineering section might have a project that centers on solar panels; a mechanical engineering course might have a project that centers on rovers).

Students are also asked to learn and practice communication strategies in the context of their design work. Engineering and communication faculty instructors co-develop and co-teach the course.

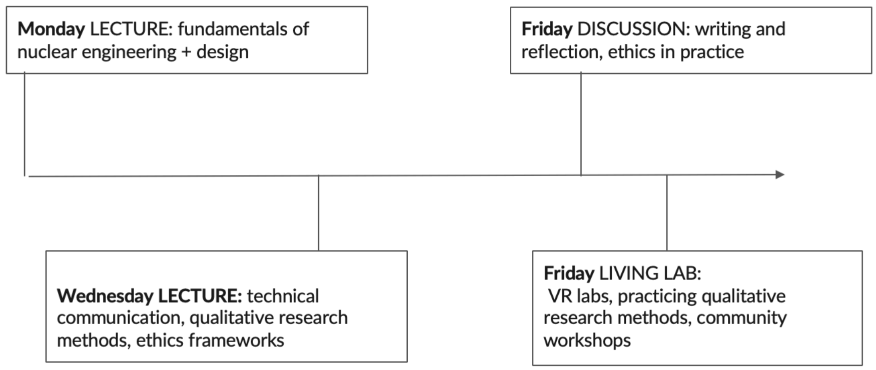

Figure 1: This course featured three components and four weekly points of contact

In our nuclear engineering section, 38 students were tasked with the imagined project of siting a nuclear reactor facility near campus. Obviously, nuclear reactors are not easily accessible to students, so we used VR models to simulate reactors, both fission and fusion. We also provided VR simulations of reactors in lived contexts, and students narrated video tours of the sited reactors as educational tools to share with community members. Lecture time was primarily centered on class discussion and engaged learning activities. Our Lab was a "living lab," where students learned and tested their design and communication skills in real-life contexts. Students used qualitative methods, like interviewing and making observations, engaged with the VR models, and participated in online and in-person design workshops with local community members. Our weekly Discussion was devoted to teamwork activities and smaller group conversations about students' progress in the course.

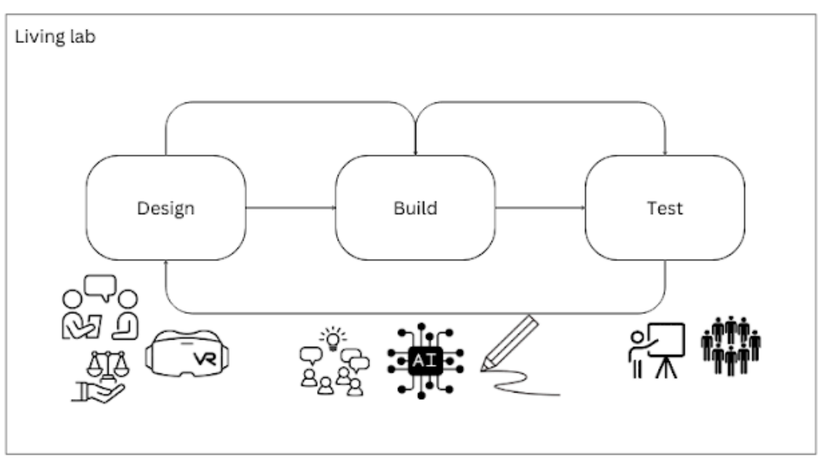

Figure 2: Embedding the Design-Build-Test Model into a Living Lab featuring community engagement

The overarching goal of our section was to convey to students that designing *with* communities is the only way to design. In other words, we did not present this approach as an "alternative" they might choose if they have time. Additional goals include the following four:

1. Equip students with the necessary skills to engage respectfully and successfully with community members
2. Reflect on and examine power, identity, and knowledge in the engineering design process.
3. Learn basic principles of nuclear reactor design and related concepts, including nuclear fission and fusion.
4. Practice designing with actual community members.

We built this course on a wide range of literature, drawing from engineering education, nuclear engineering, science and technology studies (STS), social science, philosophy, rhetoric, and technical communication (as a non-exhaustive list). The design-build-test framework is an evidence-based approach to engaged learning in engineering education [3, 4, 5]. It allows students to learn engineering concepts and skills while learning the engineering design process. This approach is particularly effective when paired with technical communication instruction, in which students also write and speak about their design work across diverse audiences. Sometimes, students design for community organizations or local businesses to solve a particular design challenge. However, the opportunity to design with community members is less common – as co-equals.

Project Influences and Innovations

In nuclear engineering, we drew on research highlighting the history of inequity, lack of transparency, and environmental damage in nuclear technology development and design. For example, students watched recorded interviews of Black and Indigenous people impacted by the Manhattan Project and Japanese people who survived the World War II bombings of their country—and then engaged in a discussion about the implications of identity and power in the development of nuclear technologies. Drawing from the social sciences, students also learned grounded theory [6] and practiced coding sections of dialogue drawn from their interview experiences with community members. Coding was quite challenging for students, but the unexpected benefit of this task was that they were more attuned to language and its nuance after this activity. While they did not have time to do enough coding to develop a grounded theory, the exercise did inform their understanding of how language and power shape communication and, ultimately, technological design.

Given the broad body of literature that informs this course, we imagine an equally broad audience who may find interest in this project. Beyond engineering education, faculty in communications studies, sociology, design, sustainability studies, and energy justice may find interest in our approach to community-engaged design.

The project features at least three innovative outcomes:
1. Embedded socially engaged design into a first-year design-build-test course
2. Teaching and learning nuclear reactor design in VR in a living lab context.
3. Prototyping with AI image generators as a collaborative design activity between students and community members.

Community Engagements

As noted above, the course's primary innovation and novel feature is community engagement between first-year students in a design-build-test course on energy design. The course materials prepared students for a series of four community engagements. The first was an interview with 1-2 people from the students' hometowns. These were conducted on Zoom, and students used an interview protocol they tested in Lab with their classmates. Interviews lasted about fifteen minutes, and students engaged their participants on their perspectives, values, and concerns regarding energy technology, climate change, and nuclear energy specifically. As extra credit, some students coded parts of their transcripts to look for common themes and to develop a better understanding of their interviewees' points of view.

The second engagement was a kind of "trial run" in which students were observers in an online workshop with participants from the local community (Community members filled out applications to join the workshop and were selected on the basis of availability and proximity to our location; none had previous relationships with students or instructors). In this workshop, participants learned about socially engaged design, energy technology challenges, and basics related to energy production via nuclear fusion. Community members shared their hopes, values, and concerns about these topics, and we invited them to reflect on how they would like to participate in the design process if something like a fusion nuclear reactor were proposed in their community. We used Mural to post and share ideas collaboratively, and we gathered in breakout rooms in small groups to give people more time to share their values and beliefs. This workshop was two hours in length. The course instructors served as presenters and facilitators, and, as noted, students were asked to simply observe the first workshop.

The third engagement was nearly identical to the first, except that students took an active role in the conversations and, in some cases, served as facilitators in breakout sessions. One student observed that the virtual workshops were "the greatest aid in learning about stakeholder needs and sentiments as well as perfecting our workshop protocol” (We have IRB approval for this project and can use student quotations anonymously).

Across both virtual workshops, the instructors were overwhelmed by the positive responses and engaging conversations that developed throughout the workshop. Participants shared that the workshop was "exciting," and they looked forward to learning more. They also said the workshop was "excellent" and "informative." Several expressed an interest in continuing to work with students in future workshops or engaging in individual interviews to continue sharing their ideas.

The final workshop was a five-hour in-person session run on a Saturday afternoon. We took a similar approach to the previous workshops in that we were seeking to learn about community values and individual values, along with hopes, concerns, and questions they might have related to nuclear energy generation. The specific project for the workshop was to develop criteria and a vision for a fusion nuclear reactor sited in or near the local community. Students worked with community members together, sitting at round tables in a ballroom to develop these ideas. The instructors provided handbooks to guide the design process, and these included opportunities for individual reflection, note-taking, and sketches. Large sticky sheets of paper were also placed around the room, each table with its own sheet of paper, where teams could post their ideas as they worked through prompts in the handbook. In the center of each table, teams also had large poster boards with outlines representing the site of a nuclear reactor. As teams talked about their values and beliefs and established criteria for the siting of their community reactor, they wrote those ideas on small sticky notes. They placed those in relevant locations on the poster board. After lunch and in the final design stage, teams used AI image generators to help prototype their imagined fusion reactor in their community context. As the workshop drew to a close, each team presented the results of the days' conversations and their reactor design to the workshop community. Presentations were given by one community member and one student from each team.

What was striking about these workshops was how excited students and community members were to engage in this process together. A community member commented on how "wonderful" the students on her design team were and that she was so impressed with their work and communication during the workshop. One student shared that the in-person workshop provided students "... a sense of responsibility for those around them by listening to the hopes, concerns, and ideas of community members." Across all ten final presentations from student teams at the end of the semester, they were unanimous in calling for community-engaged design to be the best practice for engineering design. Each team noted that their perspective on engineering and what it means to be an engineer was changed by their experience in our course. Many wrote in their final papers that designing without community members would be an act of injustice and, at the very least, an incomplete approach to the design process.

Challenges and Future Work

One challenge with community-engaged design is finding ways to reach out to community members and bring them into workshops or design spaces. We worked with a community engagement partner at the university to help gather participants. We also tried advertising on social media spaces and local newspapers, and the students already created flyers and posted them around town and on their social media sites. In addition, we committed to paying our participants $20/hour for their participation to signal that their time and expertise are valuable. Ultimately, the virtual workshops included 10-15 participants each; the in-person workshop had 22 community participants. We were hoping for closer to a 1:1 ratio with our class of 38 students.

Still, the inaugural run of the course has been completed with much success and many lessons learned. As we plan to rerun this course in Fall 2024, we anticipate several changes. Initially, we aim to develop two new virtual reactor models and provide more time for students to explore those models. One goal would be to hold a community open house in the VR lab, where students would host the participants on virtual tours of the reactors in person. These tours could be a starting point for interviews, workshops, or dialogues about nuclear reactor energy technologies and the possibility of hosting these in their community.

We also aim to lean more heavily into energy justice themes throughout the course as engaged learning activities in lectures and the living lab. Specific ideas for developing this portion of the course are ongoing and under development. Recommendations are invited!

The implications of this work are far-reaching, with particular relevance for practicing engineers looking to make nuclear energy technologies widely accessible as part of global efforts to rapidly decarbonize our energy systems. As technologies like microreactors (small reactors that might power a rural community or even smaller entities) and even fusion (not yet viable but showing promise for widespread use in the future) continue to develop, communities will have many options and choices. Practicing engineers are looking for strategies to engage community members in equitable and just ways. The model for community engagement that we are developing in this course has the potential for widespread adoption in professional contexts; this is a way to reshape energy technologies and engineering design more broadly.

References

[1] T. Mitchell. *Rule of Experts: Egypt, Technopolitics, Modernity*. 2002.

[2] T. M. Li. *The Will to Improve: Governmentality, Development, and the Practice of Politics.* 2007.

[3] D. F. Elger, S. W. Beyerlein and R. S. Budwig, "Using design, build, and test projects to teach engineering," *30th Annual Frontiers in Education Conference. Building on A Century of Progress in Engineering Education. Conference Proceedings*, Kansas City, MO, USA, 2000

[4] S.B. Andersson, J. Malmqvist, & M.K. Wedel. A systematic approach to the design and implementation of design-build-test project courses. In *DS 35: Proceedings ICED 05, the 15th International Conference on Engineering Design, Melbourne, Australia, 15.-18.08. 2005*.

[5] R. Mitchell Spearrin, F. A. Bendana, Design-build-launch: a hybrid project-based laboratory course for aerospace engineering education, Acta Astronautica, Volume 157, 2019, Pages 29-39,ISSN 0094-5765, https://doi.org/10.1016/j.actaastro.2018.11.002.

[6] K. Charmaz. *Constructing Grounded Theory.* 2006.