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Teaching Students to Incorporate Community Perspective into Environmental Engineering Problem Definition through Iterative Conceptual Site Models

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Abstract

In environmental engineering site remediation projects, community perception of environmental and health risks can influence a project's scope and design. Therefore, community engagement is critical to shaping an engineer's definition of an environmental problem. However, lower-level undergraduate engineering curricula rarely address the incorporation of community input into environmental engineering problem definition, as environmental engineering coursework tends to utilize pre-defined problems to develop and assess technical knowledge and skills. Upper-level courses that do include community participation in environmental engineering design tend to be reflective, having students evaluate the social impact of a pre-defined problem or completed project using secondary sources. In contrast to these dominant approaches, we argue that undergraduate curricula must teach students to proactively seek out and incorporate more holistic contextual information and community input in the problem definition stage of projects.

In this paper, we propose a strategy for using conceptual site models (CSMs), a commonly used tool in environmental site remediation, to integrate community inputs into problem definition for site remediation projects. Through a methodology of iterative CSM design and community engagement, we explore how different stakeholders can influence the development of CSMs, thereby enhancing an engineer's understanding of a given project's social and environmental setting. We implemented this methodology with a cohort of undergraduate students from different universities during a two-week-long summer field session experience. Students created CSMs based on their technical understanding of a historical mine site, and then updated their CSMs after a site visit that included members of different stakeholder groups. We asked students to compare their CSMs to the ideas and values of other stakeholders and describe how these perspectives changed their understanding of the contaminated sites. This module provides a hands-on example of how to incorporate local knowledge and concerns into problem definition, a skill that is necessary for developing environmental engineering projects that are socially just. Our method can also be easily adopted by educators into their own classrooms as a method of educating undergraduate students about engaging community members during the problem definition stage of projects.

Introduction

The role of engineers in society has been continuously evolving from that of a technological innovator to that of a "technical mediator," in which an engineer serves to work with stakeholders and community members with problem definition and solution development [1]–[3]. Despite this, core engineering curricula tend to provide students with all the necessary parameters to generate a single, technical solution [4]– [6], rather than having students engage in the complexities associated with working with "messy real world problems" [4]. To address this, engineering educators have worked to integrate social considerations into project design through collaboration with stakeholders as well as research into the sociotechnical nature of engineering [6]–[10]. Of particular interest to educators are strategies for incorporating community engagement as early as the problem definition stage of an engineering design project. As stated by Downey, “by successfully defining a problem one also takes possession of it, gaining control over what will count as desirable solutions” [1]. Neglecting stakeholder input during the problem definition phase of engineering design may result in solutions that are desirable by individual parties (e.g., engineers or the client) but not desirable by everyone impacted by the final design (e.g., community members).

Undergraduate engineering programs typically teach the engineering design process as a general framework useful for developing a project over its life cycle. The specific phases of the engineering design process and the vocabulary used to describe them vary from discipline to discipline, but often revolve around a few core concepts: problem definition/needs identification, generating conceptual alternative solutions, selecting the best alternative solution, detailing the selected design, and implementing the selected design [11]–[14]. During the problem definition stage, also referred to as the needs identification phase, engineers work to define the essential challenges to be addressed by the project and specify the requirements and constraints that will shape the overall design [15]. Next, engineers create several viable alternative designs that meet the requirements previously set forth during the problem definition stage. The alternative designs are further developed until one of the designs is selected as best suited for addressing the problem [12]. The selected design is then further refined, ensuring that the details match the requirements set forth by the problem definition until the design is finally ready for implementation [11], [12]. Although presented sequentially, the engineering design process is often iterative, as engineers move between the design phases as they further refine and test their designs [14]. Given the role of the engineer evolving into more “human-centered” practice, problem definition is increasingly important for project success even though engineering curricula do not always address it [13].

One method to encourage “human-centered” project design is through community and stakeholder engagement. In engineering education, community engagement projects are defined as “the dynamic interaction, dialogue, and involvement between educational institutions and their communities to achieve mutual benefits by exchanging knowledge and resources” [16]. Community engagement techniques used in engineering projects vary widely, and with differing degrees of success: ranging from top-down, one-way communication, in which community members are informed about a project and its potential impacts, to bottom-up, coproduction, in which community members and engineers jointly develop a design [17]. Two-way communication and active community member participation allows for the community to share control over decisions that affect them and can result in increased capacity among community members and greater sense of ownership of a project [3], [18]. Without empowerment of the community members, projects are likely to fail [18]. Engineers must learn to listen to local populations to work properly within the social, environmental, political and economic constraints of their projects.

Given the importance of community engagement in problem definition, instructors need methods to educate students about project co-ideation and co-production. However, few examples are available in the literature of such methods. Nelson developed a two-hour lesson plan to educate students on stakeholder engagement during problem definition stages of an engineering project. Students conducted site visits to the campus libraries and engaged in different ethnographic research methods to develop service-learning engineering projects for future semesters [19]. Similarly, Harsh et al. developed a multi-day workshop to increase student competency in three main fields — sociotechnical design thinking, listening to people, and empowering communities [3]. Leydens and Lucena also discuss some strategies in which community engagement can begin during the problem definition stage by applying the Engineering for Social Justice Framework to the engineering design process [6]. These few studies illustrate the creative potential that instructors can have when teaching students how to engage communities. Our work seeks to build off this foundation by offering a strategy that environmental engineering instructors can use to teach students about community engagement techniques for problem definition.

Environmental engineering researchers have worked to incorporate social and political perspectives into environmental engineering design projects to address increasingly complex environmental challenges. For example, some environmental engineers have called for more collaboration with anthropologists for water, sanitation, and hygiene projects as the success of these projects hinges on the co-conceptualization and co-ideation of the problem definitions and designs being implemented within communities [20]. Similarly, Mihelcic et al. specify that social scientists must be engaged in environmental engineering projects that are being used to address the United Nation’s Sustainable Development Goals, explicitly stating that ethnographic research methods and program evaluation are necessary for environmental engineering projects to successfully account for the social and structural conditions within a community [21]. Researchers have expressed interest in community engagement throughout environmental cleanup phases and remediation practices in both developed and developing communities [18], [22], [23]. Researchers have called for more stakeholder engagement throughout the entire site remediation process during discussions regarding land use, risk perception, and broader social outcomes [18], [23]. Based on the growing body of literature about community engagement in environmental engineering, environmental engineering students must learn strategies that incorporate community engagement into the problem definition stage of their project.

In this paper, we develop a module that provides a unique way to educate students about community engagement during the problem definition phase of environmental engineering design. Using conceptual site models (CSM), a commonly used tool in site remediation to guide decision making and communicating site information to stakeholder groups [22], we explore how stakeholders can positively influence the development of a problem definition, thereby enhancing an engineer’s understanding of a given project’s social and environmental setting. CSMs are iterative tools used by remediation experts to synthesize information regarding contaminant sources, fate and transport, and site characteristics to provide a better understanding of the extent of a remediation project and remediation strategies that can be used to address environmental contamination concerns [24], [25]. Engineers also use CSMs as a tool for communicating with stakeholders of diverse educations and backgrounds [25], [26]. However, only typically develop conventional CSMs and a limited number of stakeholder groups, such as site operators [25].

In a recent study, O'Brien et al. proposed a framework to expand the information contained within a CSM beyond technical data and incorporate information identified during stakeholder engagement, ethnographic field methods, and workshops and focus groups to better define the extent of and exposure to contaminants of concern. Comparison between the original, pre-site visit CSM and the final iteration of the community informed CSM shows how the problem definition evolved with further input from community members; rather than prioritizing mercury pollution, as the authors anticipated, community members expressed equal concern with pollution generated by agricultural waste, which was not anticipated by the authors. The community informed CSM was found to be a useful tool that allowed members of different stakeholder groups to collaborate on problem definition for site remediation engineering projects by identifying their environmental priorities and perceived risk of contaminants [22]. As such, we propose using the O'Brien et al. CSM development framework [22] as the basis of modules on community engagement during the problem definition phase of engineering projects.

Our module was implemented with cohorts of undergraduate students from multiple universities and has been adapted for varying modalities (in-person and virtual). Using data collected during the in-person field session experience, we evaluate the performance of the students and their ability to incorporate stakeholder perspectives into their understanding of a contaminated site. We then propose methods in which this activity can be tailored to fit into different classroom settings and curricula. This paper is organized as follows: first, we provide information on how community engagement during problem definition is typically taught in engineering education. Next, we discuss our newly developed module that introduces students to the concept of iterative, community informed CSMs. We describe the results from our experience implementing the module during a two-week, in-person summer session and highlight some key findings from student responses to the activity. Finally, we discuss limitations and future considerations for this module and offer suggestions for ways forward.

Background

Instructors have incorporated stakeholder perspective into problem definition and engineering design using different strategies, include case study analysis [27], semester-long design projects [7], [9], [28], and engineering service-learning capstone projects [5], [28]. Students are allowed to explore a topic from the perspective of numerous stakeholders by analyzing and discussing case studies, particularly if the case study is high-profile and therefore well-documented by diverse sources (e.g., the Deepwater Horizon spill). Students can use these discussions to explore "empathic perspective taking," a strategy in which students examine a scenario from the perspective of a stakeholder to gain a better understanding and level of empathy for the actions taken [27]. However, such a technique encourages reflection at the end of the engineering design process, meaning that students are examining community responses after the incident or project has occurred, rather than learning how and when to solicit community input early in the design process. Similarly, Smith and Lucena explain that the use of ethics case studies can perpetuate the idea of the status quo, in which students are walked through a decision-making process without fully analyzing how the broader context can place questions of social justice and responsibility outside the bounds of what can be analyzed or changed [29].

Instructors have used semester-long projects to educate engineering students about social considerations and community engagement throughout the engineering design process. These hypothetical projects are usually set in developing countries, and they incorporate social considerations into a traditional engineering course by making students consider the design challenges and the social considerations for the chosen site [10], [30], [31]. However, these cases often involve students either generating their own problem definition [10] or using a clearly defined problem for the basis of their project [31]. No interaction occurs between students and community members, as the entire project is based on hypothetical scenarios.

Engineering service-learning design projects often are directly tied with a community member "client" to meet community needs [32]. This community member presents the problem definition and works with the students while they generate designs [5], [7], [9], [28]. As with the hypothetical projects, service-learning projects are normally well defined prior to student engagement [5]. However, from an educational logistics perspective, service-learning projects have the added challenge of upscaling to large groups of students across multiple semesters [5], [7], [31]. As a result, these opportunities are quite rare, making up only a fraction of the capstone projects available to students and therefore limiting this experience to just a few students every year. Additional challenges to service-learning projects include communication challenges between stakeholders and students [9], [16], differences in priorities [7], and challenges with matching up project and university semester schedules [3], [7], [16]. These challenges all create difficulties when trying to develop a service-learning design project for the classroom, which may discourage instructors from developing such a program on their own. For a full review of the benefits, limitations, and barriers of service learning in engineering education, we refer the reader to Natarajarathinam et al. [16].

Although many service-learning projects acknowledge the importance of community members being the "driving force" behind an engineering project [16], there is a missing link in educating students about how to engage with communities at the problem definition stage of engineering design. Two examples in the literature of successful approaches can be seen by Lucena [28] and Silva Diaz [33]. In Lucena's work, students traveled to Andes, Antioquia, Colombia to speak with various stakeholders in the artisanal and small-scale gold mining community. During their time in the field, students met with stakeholders, visited sites of interest, and worked in multidisciplinary teams to brainstorm project ideas. From these visits, students were able to identify several projects that were based on community concerns that were vocalized during these meetings, and these projects were then implemented into semester-long design courses [28]. Another example in which students worked with community members during the problem definition stage was described by Silva Diaz et al. In this project, students served as mentors for workshops in which community designers went through the entire design cycle addressing previously identified concerns. The students' roles within this project were not to design a solution for the community-defined problem, but to collaborate with community designers to identify resources. Students assisted the community designers, who took responsibility for the entire design and implementation process. This process emphasized the importance of community empowerment in engineering projects to the student participants [33].

Methods

Module Description

Using the O'Brien et al. community informed CSM framework [22] for reference, we developed and implemented a module demonstrating how stakeholders can positively influence the development of a problem definition. This module consisted of three main parts: an initial lecture and CSM drawing exercise, an interactive site visit to a contaminated or remediated site with a diverse group of stakeholders and local professors, and a reflection exercise and revision of the CSM. The initial lesson focused mostly on the definition of CSMs and the information typically included in one. The information that we provided to the students during this lesson included a description of the information used for developing a CSM, the various stages of remediation where a CSM is developed/updated, and some examples of CSMs that were developed on past remediation projects. At this stage of the module, students only learned about conventional CSMs and focused their attention on site history and technical information that are used for the development of CSMs at this stage. After concluding with a brief discussion of the information and data required to create an effective CSM, we introduced the students to the site they were going to be visiting the following day.

We chose the Akron Mine site in Gunnison, CO to be our location for the 2021 interactive site visit: a silver and lead mine that operated from 1879 to approximately 1959 [34] and was remediated in 2015-2016. We selected this site due to its proximity to the summer session field site and due to the long-standing relationship between several of the authors and the non-governmental organization (NGO) that completed the site remediation. During the initial lecture, students learned about the history of the Akron Mine and were given some information regarding the extent of the pollution prior to any remediation efforts. We then organized the students into groups of three and provided a map of the site and limited environmental data and instructed them to develop their own CSM based on the information provided. Because students were developing their CSMs before seeing the site, we told students to write any assumptions or questions they had regarding the site so they could ask about them during the site visit. Students then presented their preliminary CSMs and discussed what information they hoped to obtain during the site visit.

Representatives from the NGO led the site tour for the Akron Mine, describing in detail the extent of the pollution at the site, the remediation process, and their experience with the surrounding community. Accompanying the students on the site visit was a diverse group of professors with expertise ranging from anthropology to mining engineering. Many of these professors also acted as surrogate community members and stakeholders. Although there are limitations using professors to act as surrogate stakeholders, we chose to do so due to the limited time available for the activity (two days). Because the module was meant to teach students how to incorporate different perspectives into project design and not how to solicit stakeholder engagement, we did not spend much time discussing with the students how we initially recruited the NGO and other participants in the study. During the site tour, we instructed students to engage with the stakeholders during the site visit, asking questions as topics arose that were relevant to their understanding of the site. Students already learned about sociotechnical engineering and stakeholder engagement in previous lessons, so they were able to draw on this knowledge as the site tour progressed. We advised the students to be attentive to human and ecological exposure routes that they may not have considered, such as water systems or infrastructure that lie outside of the property boundaries. We also encouraged the students to take notes, make annotations to their first iteration of their CSM, and try to validate the assumptions they made.

Following the site tour, students revisited their groups and amended their CSMs using the updated information that they received during the site tour. We asked the students to present their updated CSM and provide feedback on the other CSMs presented. We also presented examples of iterative CSMs in other contexts, such as the examples found in O'Brien et al. [22], to demonstrate other applications of the iterative CSM in the field. Next, students discussed the iterative CSM process and the benefits and limitations of the exercise. Some of the key discussion questions included the following:

- In what ways did your CSM evolve between the first and second iterations?
- What would you do if you collected conflicting information from stakeholder engagement or site visits? How would this influence our thinking about the site? How can this be represented in the CSM?
- What are some challenges with incorporating stakeholder perspectives in CSM?
- What information are you still missing?
- What stakeholders are you missing from your CSM?

Data Collection and Analysis

Since its development, we have implemented this module three times using different sites and different modalities. However, for the purpose of this paper, we are focusing on the 2021 experience. We collected data on how students perceived the importance of community and stakeholder participation during problem definition during a two-week summer session in July 2021 with a cohort of undergraduate students. The Responsible Mining, Resilient Communities research group, an NSF-funded project that focuses on the social and technical considerations for engineering projects with specific focus on artisanal and small-scale gold mining, facilitated the summer session and recruited a cohort of twelve undergraduate participants. The undergraduate students who participated in this summer session were from Colorado School of Mines, University of Texas at Arlington, and United States Air Force Academy. The Human Subjects Research board at Colorado School of Mines approved all activities that occurred during this field session, and all students who were included in this analysis provided informed consent. All students were entering into their junior or senior year of their undergraduate degree, and they predominantly studied civil and environmental engineering. In total, eight of the twelve students consented to their participation and materials to be included in the research. Given the small sample size available for analysis, there are limitations when generalizing the data.

After the second lecture and discussion of the module, we collected written student reflections responding to the following prompt:

> *Describe the differences between the CSM that you developed today from your site visit and one that a stakeholder of the Akron Mine site remediation project would develop (specify which stakeholder group you are using in your reflection). What are some of the benefits of incorporating this perspective into our CSM?*

All responses were anonymized. The first author analyzed student responses by using inductive grounded theory, in which recurring themes were identified while reading student responses, which were used for the development of hypotheses and theories [35]. Once themes were identified, we reviewed the student responses with these themes in mind, allowing for further analysis of students' responses to this experience.

Results

Students developed a more robust understanding of the importance of community engagement in problem definition using CSMs. By the end of the module, students were able to articulate how stakeholder engagement can impact the development of a problem definition and explain how a CSM can be used as a method of compiling both technical and social data into a document that illustrates a mutual understanding between engineers and community members on the environmental concerns at hand. Three key themes emerged while reading student responses: specificity (i.e., students were able to provide specific details about different stakeholder groups' perspectives), community value identification, and risk perception analysis. Student responses consistently demonstrated these themes and are discussed in further detail below.

After this activity, students were able to articulate the benefits of incorporating stakeholders into early problem definition by using specific examples of stakeholders from the Akron Mine site and their knowledge. Several of the students reflected on how an outdoor enthusiast may have responded to the changes at the Akron Mine site, which had previously been used by the local community as an area for dirt biking or other recreational activities. One student commented, "Considering a CSM from this differing perspective might allow us to predict how the public interacts with this remediated site." Another student stated, "...when we were talking about possible exposure pathways to pollutants, we did not consider the dust that dirt bikes could stir up." A third student talked about collaborating with NGOs and how "NGOs can provide guidance by acting like a mentor or by sharing previously found information." Students also identified downstream residents as stakeholders to be considered when developing CSMs, describing how their knowledge of the area, particularly about outdoor recreation activities in the neighboring National Forest Service land, may impact exposure pathways and thus necessitate the use of different remediation options and institutional controls to protect both the community and tourists in the area.

The CSM was also considered as a method to identify local community values. Students were able to articulate the values of different stakeholder groups and use that understanding to better understand the social conditions of the Akron Mine site. One student expressed this in their written response:

> "…if the CSM is developed by outdoor enthusiasts as stakeholders, then the elements of interest might change and they would find more valuable information about hiking trails, parking areas, types of vegetation and animal life present, other attractions nearby, … [and] entertainment activities."

This response illustrates that the student was aware of the relationship that the community in Gunnison, CO had with the natural environment, in which they perceived to be extremely valuable. After hearing about the responses that community members previously had when confronted with the possibility of a mine opening nearby, the student saw that the community was concerned with protecting their natural resources. Another student discussed how they shared many values with the community, saying, "As both an engineering student and a dirt bike enthusiast, I can appreciate the differences of each perspective." This student cites their mutual interest in outdoor activities, illustrating a degree of empathic thinking between the student and the stakeholder group.

Students also talked about differences in risk perception between engineers and community members when discussing the iterative, community informed CSM. One student stated, "Having the stakeholder perspective is important because there is a different opinion on what is wrong or could go wrong on site." Another student expressed a similar idea, writing, "[The community] might be afraid of a 100-year flood event or worse that might cause the floodplain to overflow and interfere with the site. Though unlikely, this event could occur." This student then went on to describe how utilizing stakeholder engagement early in the project makes the engineers take a more critical view of a site that may not initially be considered "contaminated," saying, "Once we add in the perspective of someone who is directly affected by the potential contamination, we look at the site with a more critical view." These comments demonstrate that the students are beginning to consider one of the most challenging questions with regards to socially responsible site remediation: do the target remediation goals set by regulatory agencies match community members' perception of remediation [23]? Students were able to articulate how the amount of risk that is acceptable to an engineer may not be reflected by the downstream community and relate that to problem definition in their modified CSMs.

In summary, the students who participated in this activity demonstrated growth in their understanding of the importance of stakeholder engagement during problem definition and their ability to use the iterative, community informed CSM as a tool to accomplish this. Every student's written response reflected that these students were able to specify different stakeholder groups to engage during the problem definition stage of a site remediation project at the Akron Mine site. Multiple students were able to list reasons why diverse stakeholder perspectives would meaningfully add to the problem definition stage of the engineering project, whether it be that stakeholders could help engineers identify the community values that can influence a site remediation design or risk perception that may inform how stakeholders engage with a contaminated site. This module shows the potential that a similar lesson can have in teaching students to incorporate community voices into their projects.

Limitations and Future Directions

Despite using the O'Brien et al. iterative CSM framework [22] as the basis of the module that we developed, there were several notable differences between the techniques used in the CSM framework and those used over the course of our two-day module. Notably, our module was significantly condensed in comparison with the methods employed by O'Brien et al. [22] to accommodate the short-term summer session in which the module was being taught. Although students did not experience the same degree of stakeholder engagement and analysis as that proposed by O'Brien et al., we believe that this shorter module illustrates the potential that such a module can have in providing hands-on experience with problem definition. For example, instructors can modify our short, two-day module to eliminate the need for a site visit if one is not feasible for the group of students by using virtual site visits and connecting with stakeholders to develop a CSM. While developing the module, we implemented a virtual strategy with a cohort of engineering students from Colorado School of Mines, United States Air Force Academy, and Universidad Nacional de Colombia Facultad de Minas due to logistical challenges with traveling to artisanal and small-scale gold mining sites in Colombia. We initially grouped students with members of their respective universities and tasked them with developing a CSM of an artisanal and small-scale gold mining site. After students presented their initial CSMs, we rearranged the groups of students so that representatives from each university were present in each group, and we tasked students with developing a second iteration of their CSM [36]. Students were still able to learn about the importance of incorporating different perspectives into their CSM design by observing how their understanding of the problem definition evolved when interacting with people of diverse backgrounds and disciplines.

One limitation of this module as it was taught is the groups of stakeholders that were selected to participate in the activity. As previously stated, the stakeholders who were involved with the iterative CSM development for the Akron Mine site were limited to a single NGO and a group of professors to allow for the limitations in time and scope of the module. While many of the professors involved in the activity were residents of the region that surrounded the Akron Mine site, they fail to serve as a representative group for all stakeholders that impact or are impacted by the Akron Mine site and its subsequent remediation. Students were only exposed to stakeholders with degrees of knowledge about mining pollution and site remediation practices, which may not reflect the degree of knowledge that neighboring communities may have about a site. Because of this, students may expect stakeholders to possess high levels of technical knowledge, and thus be surprised when stakeholders may be unable to provide the technical information that students may feel like they need for the problem definition phase of a project. Additionally, these stakeholders were willing to commit the time and energy to provide a site tour and answer student questions, which may not be true for all stakeholder groups involved with a site. As such, if this module is to be repeated in the context of an engineering design course, it runs the risk of perpetuating the belief among students that the stakeholders should be expected to provide the same high degrees of preferential treatment, whether it be through site access or through time commitments, a concern that was vocalized in a similar problem definition exercise conducted by Nelson [19].

Additionally, given the time constraints associated with our summer session, we were unable to develop an activity at the end of the module that would allow students to solicit feedback from the stakeholder groups on their updated CSMs. Obtaining feedback from stakeholder groups on the second iteration of the CSMs is important for open, two-way communication between stakeholders and engineers, as it is possible that the modified CSMs still fail to capture the community's priorities. Failing to demonstrate the importance of soliciting stakeholder feedback on the iterative, community informed CSM may cause students to infer that this process only needs to be done once, rather than an iterative process that continues until a problem definition can be agreed upon by all stakeholders involved in the project.

We recommend a few modifications to our module to address these limitations. Instructors can add to the class discussion at the end of the module to address misconceptions regarding stakeholder participation and engagement. Encouraging students to consider the social and cultural norms that may impact stakeholder participation is crucial so students are cognizant about barriers to participation. This discussion can be in response to the question, "What stakeholders are you missing from your CSM?" by prompting students to think critically about who was represented in their CSMs and why they were more likely to actively participate during the site visit. Instructors can also take advantage of virtual meetings to interact with stakeholder groups who may not be able to attend a site visit to engage a more diverse stakeholder population during the module. To address the lack of feedback on updated CSMs, instructors can assign students to develop a final presentation based on their community informed CSMs that would be given in a hypothetical meeting with members of different stakeholder groups (e.g., a town hall meeting). Students would be asked to present this updated CSM to the class and develop a series of questions that they may have for the stakeholders to evaluate whether their understanding of the problem definition matches stakeholder expectations.

Conclusions

As the role of the engineering profession continues to evolve to meet complex current and future societal challenges, students need to be prepared for working with diverse stakeholder groups throughout the entire engineering design process. As such, several researchers and engineering educators have developed strategies to educate students about how to incorporate community perspectives as early as the problem definition phase of the project. Our module builds on this progress by providing a unique strategy for teaching students to engage community members during problem definition using iterative CSMs. Using a combination of site visits and communication with stakeholders, we walked students through an iterative CSM process to identify how problem definitions change when incorporating different stakeholders' perspectives into the overall understanding of a site. Students were able to evaluate the limitations of a purely technical CSM and how it may lead to a problem definition that fails to account for community values and expectations. Student responses that were submitted after we taught this module demonstrated this growth; students clearly articulated the benefits of incorporating stakeholder voices into a CSM, listing aspects such as improved exposure assessments, better understanding of community values, and directly confronting areas of potential conflict between stakeholders and external engineering firms. This module can easily be added to engineering design curricula, and it provides a tool that students can readily implement in future engineering projects during their career.

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