Instructional Strategies for Incorporating Empathy in Transdisciplinary Technology Education

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Abstract

In the past decade, there has been an increasing focus on the ethical content of designed artifacts, including the ways in which engineers and technologists are responsible for considering ethical issues relating to the end user or context for which they are designing. Creating sustainable post-secondary ethics education has been an increasing focus in engineering and technology education scholarship, with the goal of developing students' ability to understand and make ethically-sound design decisions through evidence-based instructional strategies.

In this study, we focus on the ways in which a transdisciplinary educational experience might encourage the development of empathic ability by documenting the activities of undergraduate technology students as they sought to develop an off-the-grid toilet for the "developing" world. Students were exposed to multiple instructional strategies that encouraged them to reconsider their notion of "difference" as it might apply to their semester-long design project. We present several themes of instructional strategies that emerged from instructors and students, and contextualize these strategies in relation to the students' development of empathic ability. The students in this course struggled to develop empathy that had practical implications for their design activity, suggesting the need for a larger shift in the ability of students to create empathically-driven action. We found that a substantial change in empathic ability also requires a certain amount of vulnerability and ability to position-take (i.e., taking the position of another), indicating the need for "safe spaces" that challenge student perspectives while also encouraging trust and honesty.

Introduction

In the past decade, there has been increasing concern about the ethics and values that are inscribed in the designs that engineers and designers produce[1-4]. This ethical shift is partially a result of an increased focus on the social impact of engineering[5,6], and a growing awareness of the socio-technical complexity of designed solutions, particularly relating to the user and use context(s)[7-11]. However, as approaches such as *design thinking* become increasingly mainstream (e.g., Dym et al.[12])—both within and outside of engineering contexts—the call for ethically-centered design practice has emerged as a primary concern for design educators, practitioners, and policy makers[13-15].

Consideration of ethics within the landscape of human-centered design processes requires a commitment beyond technical excellence[2,16]. Designers must also produce solutions that work safely, effectively, and efficiently. Petroski[17] popularized the complexity of designing for human beings, demonstrating that it is not enough to design within the system of an engineer's personal ethics or technical capability. An ethical designer must also consider the human use of their solutions. To consider the complexity of real-world use requires empathy on the part of the engineer or technologist, and indeed, empathy has been mentioned as an important component of being a successful practitioner[9,18,19]. While there is now general agreement that empathy is a desirable—if not crucial—characteristic of engineering practitioners[9], we do not yet have a full sense of what instructional approaches are capable of developing a student's empathic ability, or how such methods relate to the learning experience.

Definitions of Empathy

Empathy has been addressed at length in psychological, anthropological, design, and engineering contexts. Empathy is frequently mentioned as a key ability that students must develop in order to understand the role ethics and values can play in a design process[9,11,19].

Within engineering education, the terms *empathy* and *care ethics* have been used by scholars to address the important connections between the ethical fabric of engineering as a discipline, and the ways in which we can activate our ethical commitments by empathizing with the end user. It is important to note the role of ethics across this exchange, both in informing our motivation for generating empathy (e.g., human-centeredness) and in indicating how we respond to the information we gain in the context of our design activity. Scholars have addressed these two applications of ethics in differing ways. First, taking an ethical position that values the lives and needs of end users requires engineers to view their practice as always already being infused with the daily activity of providing care[9,20-22]. This positioning of care as a moral imperative stems from care ethics literature and the work of Joan Tronto[23], and is particularly beneficial in framing the work of engineers in identifying societal needs and potential solutions to those needs. Both framing and solution-generation processes require consideration of the needs of end users. Second, taking an ethical position requires engineers to consider their role in solving a societal issue; technical expertise is necessary, but not sufficient to meet many of these challenges. Rather than viewing the engineer as a "savior" to the developing world due to their technical expertise, a focus on ethical commitments of empathy require the engineer to contextualize technical innovations in context[7,24,25]. Viewing the developing world solely through the eyes of a technical challenge often ignores the societal framework and other considerations (e.g., climate, availability of resources) that may disallow Western advances in technology to be applied in a direct manner. Empathy that is carried out in a user-centered way uses technical skill as only one of many skills that can be brought to bear in the design process.

Previous work on empathy in an engineering education context built on the user-centered paradigm addressed in the previous paragraph—expanding students' ability to understand multiple perspectives of a problem, then using these understandings to identify more appropriate design solutions. Empathy has been seen alternately as a way to encourage innovation[26] and ideation[19,27], creating a discourse that values effective communication as a means to generate awareness for potential solutions[11]. The work of Walther, Miller, and Kellam[11] also builds on a definition of empathy from Levensen and Reuf[28], which consists of three ascending stages: *knowing* (primarily cognitive), *feeling* (primarily emotional, and consistent with care ethics), and *responding*, (primarily action-oriented). Campbell[7,24] has addressed the issue of empathy more indirectly, using the notion of "caring" based in care ethics to understand how engineers relate to end users through the solutions they produce—ultimately inculcating an understanding of designer responsibility into engineering students that grounds them ethically.

Instructional Strategies to Promote Critical Awareness

A variety of instructional strategies have been used to promote critical awareness of engineering and design activity in a classroom context, drawing on principles from human-centered design[29,30], empathy[16,31-33], value-sensitive design[34-36], and feminist theory[37,38]. Many approaches to building empathy relate to the development of communication competencies—allowing students to enter a discourse that is shaped by multiple perspectives, including that of the user[11].

Feminist theory is another common mechanism for bringing the idea of multiple user subjectivities, care, and empathy into engineering and design education, by building a diversity of understanding of power and agency within disciplines that have traditionally been dominated by notions of technicality[37,38]. Once the values and ethics that underlie design action are available for conversation, techniques such as value-sensitive design (VSD)[35] or "value levers"[36] may be used to probe into the values that engineers and designers implicitly inscribe in the solutions they create, first seeking to identify areas where values might be problematic in terms of eventual use, and then using approaches to see the situation differently and adjust the solution accordingly.

All of these approaches fit within the broader framing of the professional identity formation of the engineering or technology student. [18] and [39] have identified that social competencies learned in a classroom environment have a substantial impact on the way that student will come to understand and shape their own practice, underscoring the importance of deeply considering the messages that are conveyed in a classroom setting. This identity formation—when stimulated by diverse ethical framings—should allow the student to integrate their understanding of the user and her context in their design process, recognizing the interplay between technical ability and the sociality of use[40]. This process involves the use of empathy on the user's terms, not those of the designer, and thus requires the understanding and integration of perspectives on the world that are truly in service of the user [25].

Research Focus

In this paper, we present results from a one-semester design studio experience, where undergraduate students in a transdisciplinary technology-oriented program designed solutions to address the sanitation crisis in the "developing world." Students were provided with the "Reinvent the Toilet Challenge"[41] as a baseline for their design activity. This created an environment in which it was assumed that students would empathize with their target user population (as in Campbell, Yasuhara, and Wilson[7,24]) in order to develop a solution that would be appropriate and beneficial to the end user.

We specifically focus on the following research questions:

1. What are the instructional strategies used to foster the development of empathy in a transdisciplinary technology education design studio?
2. Did students evidence empathic development as a result of these strategies?

Method

Our data collection included artifacts from the project development process, including whiteboard sketches, deliverables, and the final project from each team. In addition, we captured classroom interactions through extended observation, video-recorded group presentations, and interviews of the course instructor and students at the middle and conclusion of the semester. Data analysis focuses on the instructional strategies and design tools that were introduced and used by students and the instructor to foster a sense of empathy on the part of the students, drawn from observations of classroom activity, and triangulated through presentations and interviews. All data collection activities were approved by the institutional review board as part of a larger

study related to the transdisciplinary educational environment under IRB protocol #14070015052.

Participants and Context

Participants included 13 students enrolled in a one-semester design- and technology-focused *Design Lab* studio experience at a large Midwestern research university. Participation in the Design Lab was required as part of an experimental, transdisciplinary, competency-based undergraduate degree program. These students were simultaneously enrolled in a humanities-focused *Seminar* experience. Both the Design Lab and the Seminar addressed topics related to "differences" and to the global challenges presented by human waste. In the seminar course, students met for two hours each week, to discuss readings and engage in activities related to a number of topics, including feminist theory, issues relating to gender, and bathroom practices in the United States. Meanwhile, students met in design lab for six hours each week, with the goal of creating a targeted solution for the Bill and Melinda Gates Foundation "Reinvent the Toilet Challenge"[41]. Students were organized in four groups of three to four students each for the duration of the semester. Based on initial research and personal interests, each group selected a region (e.g., Southeast Asia, Sub-Saharan Africa) and specific city within their chosen region over the course of a two-week period at the beginning of the semester, resulting in different areas of targeted focus.

Within the larger degree program, students are required to attain a variety of competencies as part of their degree program. The focus on "difference" in relation to bathroom practices within the academic semester focused on in this paper foregrounded several competencies, including those focused on ethical reasoning. While there were no explicit instructional outcomes that related to empathy, it was expected that students would need to engage empathically with the design problem in order to develop a satisfactory solution for their end users.

Data Collection

Our data collection efforts were focused on the Design Lab course experience. Our primary collection activities consisted of naturalistic observation[42,43] of all classroom activities throughout the semester. For each class session, two researchers observed the classroom, using handwritten field notes as a primary means of data collection. After the observation was complete, these handwritten field notes were combined into a shared digital field note that incorporated the perspectives of both researchers. These field notes were then shared with the course instructor, who verified the accuracy of the notes and provided additional comments when possible that enriched our understanding of the instructors' intentions and pedagogical strategies.

In addition to the primary observation record, students and instructors were also interviewed using a semi-structured protocol that included questions relating to their project work, understandings of empathy, and course experiences for approximately one hour. Students were interviewed in the middle of the semester and at the beginning of the following semester; a subset of instructors from Design Lab and Seminar were interviewed at the conclusion of the semester. All interviews included questions about the students' development of empathy, instructional strategies they experienced or contributed to, and the ways in which Design Lab and Seminar experiences contributed to their project work.

Data Analysis

Data analysis was completed in several iterative stages. First, we conducted an emergent thematic analysis of the mid-semester student interviews, using an open coding approach[44] to identify strategies, approaches, or mindsets that students used to engage with their target population in an empathic manner. Based on this open coding, themes were clarified and organized using an axial coding approach[44], resulting in two primary clusters of codes. These clusters were then triangulated with observation field notes, instructor interviews, and classroom artifacts (e.g., whiteboard sketches, project materials), which will be presented in the next section.

Findings

In the following two sections, we will discuss the primary clusters of themes that encapsulate instructional strategies that allowed students to consider and more completely empathize with their target user population: problem framing and criticality and position-taking. Each theme will be expanded upon below, including relevant instructional strategies and examples from interviews and observations. Quotations from observations will be indicated by date, and all instructor or student references are included via identifiers (e.g., i_01 for instructor; s_01 for student) to ensure the anonymity of participants.

Problem Framing

Problem framing strategies were used to narrow the problem to an acceptable level so that students could engage with a specific user and use context, creating a targeted solution. Subthemes in this cluster address the process of student teams identifying a potential target context, conducting research to more fully understand the needs of users in their chosen context, and the ways in which their understanding of local issues changed their perceptions of waste management on a global level.

Identifying a Project Context

This theme addresses the cognitive processes students used to break down the design problem, moving from a continent to a specific region or city. In particular, this process brought out an understanding that continents are not homogenous in culture or religion, and thus require differing design approaches. The Design Lab instructor began the semester by asking students to address the human waste crisis in the developing world:

> i_01: *Here are major geographic spots of the world where safe and sanitary human waste removal is a problem. The first week was to pick an area of the world, pick a country in the world, do a little research and pick a town. And then from there, research that place and everything you can find out about that place to better understand the people who live there.*

The students focused on this framing of their project and the research that would follow for around a quarter of the semester, identifying four unique regions in the developing world to focus on: Maroua, Cameroon; Cambodia; Addis Ababa, Ethiopia; and Bangui, Central African Republic. Only two students in the class had experience in the regions they were focusing on, one of whom had grown up in Africa, and another who had visited Cameroon on an extended summer trip. The students were able to identify information about the broader region, but as their

context narrowed to a single city, they were less focused and more likely to make their selection based on a single characteristic:

> s_07: *[Bangui] had water supply. And we felt if we picked a desert it'd be very hard for us to help out. So we decided to do someplace that had rivers, it was away from everybody else's locations so we wouldn't get confused or wouldn't be idea-stealing. So it was random but biasly random the way we picked CAR [Central African Republic]. And then we found out all this stuff and then I gained the empathy after learning this stuff. Because I understood in the minute way what they were feeling.*

> s_04: *There's all these different cultural beliefs and things that their region believes that our region is a little more modern. It's the capital of the country, or whatever it is, the state. Just through our research, that's a very important aspect of the design, whether they will actually use it or if they completely don't believe in that and they'll never use it, so we'll just be giving them a hunk of technology and they'll never use it. It's been a big, important part of that, is figuring out their cultural understandings and things like that.*

This process did not go seamlessly for all groups, as some students were overwhelmed with the complexity of choosing a specific region to focus on. In the first week of the semester, one team interacted with i_1 as they struggled to select an appropriate site to focus on:

> *The students state that their group problem is that they cannot find a place. Every place they find already has a toilet and that they need more time for research to determine the location for this project. The instructor states that this is the process: determine a place, and continue the research in the surrounding area to narrow their location. The instructor proceeded to assist the students on a laptop to pinpoint a target area based on their previous group research.* (Fieldnote 09022015)

As students narrowed their focus and did more research, they began to build an understanding of their chosen country as in a more personal way—understanding it as a something beyond a land mass, and as a place where people actually lived:

> s_01: *Didn't even know it existed. I'd heard about Cambodia and stuff as a country. That's the thing. […] Now, it's across the other side of the world. It's just a land mass. Cambodia was just a landmass and I had no idea what was going on there. Sometimes you don't even realize of people.*

> s_08: *No, we definitely had to do a lot of research on the specific country because every country is unique in their own way. We don't know if they have the exact same culture as we do. That's all found in research.*

Throughout this selection and narrowing process, the instructors provided tools such as fishbone diagrams (Figure 1) to allow the student teams to deconstruct the specific frames of the problem within their region, leading to an increased understanding of sanitation norms, cultural taboos, weather, and access to resources.
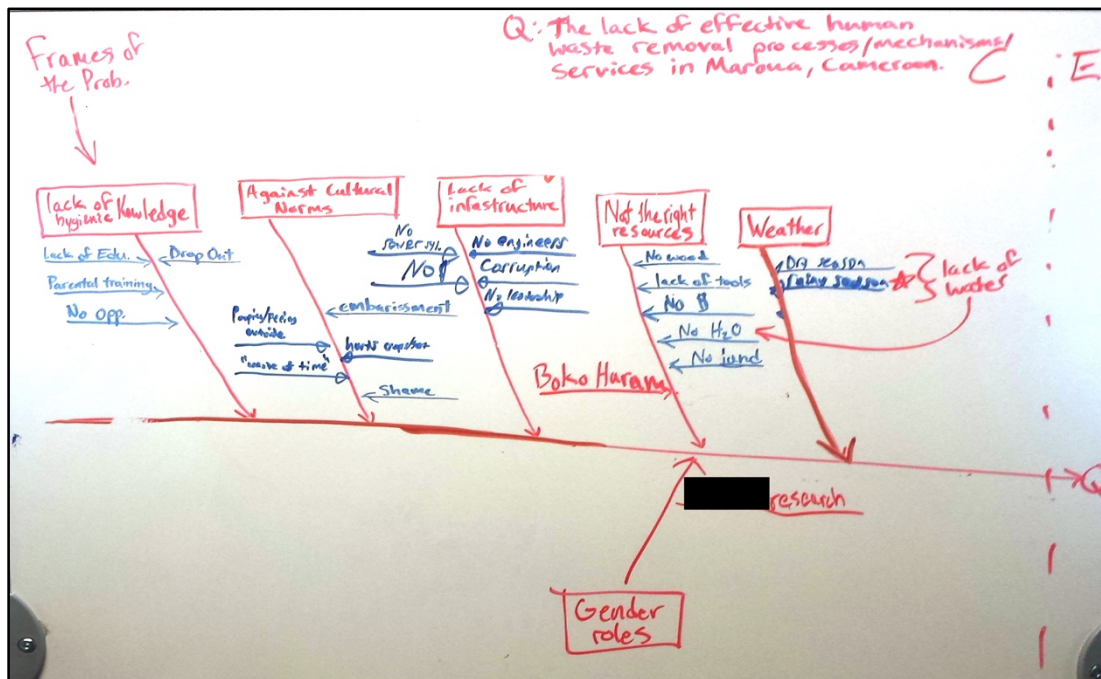
Figure 1. Fishbone diagram used by students to identify potential causal factors.

Research to Drive Insights

This theme addresses the ways in which students conducted research on their chosen context, and how this research guided their understanding and definition of the problem, leading to design insights or imposition of design constraints. According to the primary Design Lab instructor (i_1):

> *There was somewhere between two and four weeks of just continuing to do research. Looking at state department resources, other resources that [i_2] suggested. And newspaper reports, all sorts of anything they could find that would give them information about what it's like to live there. And the one team had the opportunity to draw on the one student's experience there over the summer. [One] other team had the opportunity to actually interview two people who currently live in Cameroon.*

Instructor i_1 challenged the students to do research to build a rich understanding of their design context, explaining: "*You need to understand this place. Not your place, but that place.*" This focus on understanding the true needs of their user population drove two of the teams to interview individuals they knew that lived in Africa, a byproduct of two of the students having lived or visited various parts of the continent.

> S_02: *We're doing Addis Ababa, Ethiopia. I think it was just this past summer, he went there and so he had connections there. We got a hold of them to start out with...really before we did a terrible amount of research, we got a hold of them and said, "Hey, so we're doing this toilet project and we want to know, kind of, what your outlook is on, you know, the facilities you have there now. And what they would consider to be a westernized toilet system and which they would prefer and what not?" [...] I guess the*

nice thing about that was that we got an inside look on what they think from over there. And obviously it was only a couple of people, but it at least gave us more of an understanding than what we would have to start out with.

S_03: *We actually interviewed two people who live there. I grew up 30 minutes away from the area we picked, and I knew people there, and so we Skyped two of them and got to ask them questions. We came up with an interview sheet and asked specific questions about topics. We had to translate from French to English, but yeah. […] We got firsthand accounts, I guess, which is great for developing empathy.*

Through the process of conducting primary and secondary research, the students built their understanding of waste management outside of a Western context, with s_2 remarking: "*I guess in my mind I've always thought—and this is like something that we learn here in the Western hemisphere—that is, to some degree, you always assume that people have accessibility to toilets and stuff like that.*"

Most groups used Internet sources to gather information about their topic, guided by one of the Design Lab instructors that shared her expertise in information literacy. Students' research commonly included statistics, reports, and news about the areas with which they chose to work. Students also discovered resources that fueled classroom discussion and a broader view of sanitation practices outside of the United States. For example, in the third week of the semester, one group located a documentary film on YouTube that gave them more information about the area they were focusing on. The team leader for that group, who had spent a substantial amount of time living in Africa, shared the resource with the instructor, who then showed it to the whole class:

As class resumes, the instructor mentions that s_8 has found a great resource for their research. The student then takes the lead to explain the video and what it is about. The student indicates that this would be a good resource about Water, Sanitation and Hygiene (called WASH among people who work in this area) and he found interesting the issue about understanding cultural differences, in order to propose a project. s_8 explains that the next speaker on the video talks about how the west comes to fix problems, but come at it from the wrong direction. i_1 says that this summarizes the discussion from last week—that people come in and make solutions from their own mindset without understanding the needs and values of the people who live there, and then they won't use it. (Fieldnote 09142015)

This video was a catalyst for i_1 to discuss the role of water in Sub-Saharan African contexts, and the ways in which the social and political environment may inform specific design constraints. As the students began to develop a more specific understanding of their population, they began to set specific, culturally-inspired constraints to frame their understanding of the problem further. One team identified potential limitations to their design by talking through the unique cultural limitations of their use context:

s_07: *We need something that's portable. So the portability needs to be something that's with their culture. It can't be men and women sitting on the same stool or whatever. It's supposed to be a one-person thing like we designed. So knowing them and part of their*

culture of not using the restroom as the same person—You know what I mean? Essentially we know them better now because we were trying to design something for them. We thought of ideas, "Well, do they like this? Would they like this?" So we did more research. So from the beginning to now we definitely have a better idea of the people we're trying to serve.

i_1: There was a great conversation with the students who were talking about Cambodia. And they had been talking about designing a public use toilet and how that would be a really great solution because it's sort of maximizing volume and whatever. Then they continued to do more research on Cambodia in this particular area and discovered that a significant number of violent attacks based on political differences occur outside public restrooms. Because people have to go to the bathroom, you can find somebody there. So they immediately shifted gears and said, "Maybe we need to not look at a public restroom solution."

It is notable at this stage that students did not reach out to other people on campus, even though the student body was quite diverse. Their research was limited to Internet sources and their personal contacts in other regions of the world, substantially limiting their personal and sustained connection with their target user. One of the instructors (who normally teaches graduate theatre students) remarked on this limitation, shifting the blame onto his own lack of interaction with international students: "*the students' lack of outreach to students on campus from various ethnicities and cultural backgrounds also reflects my very shelteredness in this corner of campus. I don't...there are no international students who take theater. So I don't engage in those students very often here on campus. So I think we can't necessarily put that on the students either.*" He continued, noting that the students did a reasonable amount of research, but that the "*biggest barrier for them right now would be for those people to actually test those things.*"

This theme was strongly reinforced when a cross-cultural group of panelists were invited to attend and critique the students' final presentations. Panelists remarked several times that they knew people from the targeted regions on campus, and wondered why none of the student groups had thought to contact the international student organization on campus. Students also made little use of close-at-hand resources, including Teaching Assistants who, although they did not come from the specifically targeted regions, had experienced the move towards Western toilets in their own lifetime in their own home countries. Another panelist with expertise in plumbing had led a number of study-abroad activities in which she and her students had led construction efforts in a developing nation. She indicated that had the instructor or students contacted her earlier, she would have been able to lend her expertise and share experiences.

Expansion from Local to Global Awareness

This theme addresses students' expansion of understanding about the scope of affect regarding sanitation practices and waste disposal from a local to global context, particularly in understanding that local phenomena regarding waste disposal often link to larger global or societal issues. As students drilled deeper into their fishbone diagrams, which prompted additional targeted research, they discovered systemic issues that were driving the sanitation crisis in their context. s_3 reflected: "*I thought more of the problem was general lack of hygienic knowledge, but it turned out to be more weather based, and issues of water and weather, so rainy season and dry season.*"

In the middle of the semester, the students took a trip to a local waste management facility to get a better sense of what infrastructure was standard in the United States. This brought about interesting conversations and connections among the students based on their research, as they discovered unexpected limitations in the sanitation system—even in an industrialized nation:

> i_1: *I think one thing, it was almost kind of self-centered, I think. They were very surprised that in America, in Lafayette for example, we didn't have a two-tank system which means that if you get overflow it just dumps sewage out to the Wabash. They were very surprised about this. This impacted them. [...] Right, because it was close to them. It was the river and a lot of them are from Lafayette. And then they start thinking about how we get our drinking water, they think from the river. I don't know, you can make the argument maybe that it's empathetic. We talk about places that don't have great sanitation and they stop seeing maybe the U.S. as this this flawless system. They can see maybe we're all in the same boat. But at the same time it's very much, "This is my water." It was still very self-centered.*

As the students' understanding of the connections between sanitation and society grew, they also tended toward a self-centered understanding of the problem (designing based on the designer's own assumptions of need), as illustrated in the example above. There were also differences in students' ability to raise and understand issues within or beyond the local context, particularly relating to social or cultural norms that were difficult to contextualize in a Western context. A description of a team conflict over the social environment of use described by i_1 is included below, which illustrates this issue of empathy not always being developed equally across all students:

> i_1: *And [s_7] brought to the table a fair amount of research, relatively speaking in terms of scale for the rest of the class, on sexual assault in Cameroon, which was the area [their] team was working on. And that that was distinctly tied to shame in terms of public defecation or urination for women and predatory behaviors related to private restrooms. So women go far away from everybody else in unlit areas to go to the bathroom and that's where they get assaulted. And [s_7] wanted their design to address those issues. [...]in the act of reassessing the design specification, the problem framing, [s_8]'s statement that there was no—from his perspective, there was no way to design amid all the other elements of the problem framing and also solve that problem.*
>
> *And so he said, "We can't do that." He didn't realize that saying that alienated [s_7]. And I said to both of them in different ways, to [s_8], "How do you make sure you don't do that again? Because you may be right. Maybe there was no way to do all of those things. But you all collectively have to come to that decision, not just you saying it." And I said to [s_7], "He may have been wrong, but you need to be able to engage in a conversation about the whole problem framing picture and emphasize why you think it can be included."*

One of the instructors later remarked that s_8 had done substantial research about sexual assault in Cameroon, "*and that that was distinctly tied to shame in terms of public defecation or urination for women and predatory behaviors related to private restrooms. So women go far away from everybody else in unlit areas to go to the bathroom and that's where they get*

assaulted. And she wanted their design to address those issues." In this conflict, the other students in the team could not understand that the issue of assaults on women was not a side issue which could easily be moved to the periphery, but rather it was central to the cultural difficulties that would impact the utility of their solution. This is one example of a chosen technical constraint—inspired by the team's research on the region—trumped consideration of other valid cultural concerns.

Criticality and Position-Taking

Criticality was used to position students to think about "difference"—both on a social/cultural level, and also in relation to gender and privilege. To be critical in design activity explicitly requires the designer to position-take on behalf of another[43], a key element of empathically engaging with a user. Subthemes in this cluster address the students' discomfort in learning about feminist theory and gender issues in Seminar, and the lack of application of critical issues relating to difference (particularly in relation to children and females) to the students' toilet solutions.

Discomfort in Engaging with Feminism and Gender Issues

This theme addresses the students' discomfort in learning about feminism and gender issues, particularly based in a set of readings and discussions they had in the Seminar course. While the perspectives on feminism were deemed to be valuable in expanding students' notion of difference and privilege, they felt as if their perspectives were not being adequately represented, leading to a feeling of having things "forced" on them, or that they should feel guilty as a primarily male group. This experience in the middle of the semester hampered the students' ability to understand and empathically act on gender-related issues in the Design Lab project.

Many of the students came from a more conservative or religious background, which affected their comfort in hearing alternate viewpoints, particularly in a room dominated by men. s_7 explained his experience in Seminar, noting that feminist theory is "*against the male-dominant role. I'm not saying that's good or bad or anything like that, I'm just saying with a room full of guys and the subject matter being feminism it's awkward.*" s_3 felt similarly uncomfortable, telling us that one student was emotionally impacted by the topics being shared in seminar, bringing up "*past hurts and pains, and really bothered this student. I could see it, and several teachers noticed it, several of my friends noticed it, and it worried me a bit.*" Beyond these issues of discomfort about the topic, some students also felt that they were being backed into a corner where anything they might say from their own perspective might have the potential of harming the few females in the room. This was echoed by s_7, who told us: "*I have a hard time trying to say anything without possibly offending somebody.*"

One of the Seminar instructors felt this lack of interest and concern by some of the students, noting that a couple of students expressed discomfort over talking about these issues with their peers; ultimately, this instructor said: "*from the other perspective of most of the students, they just don't like it. They don't see value in it.*" This underscores the stark difference in the learning experience as viewed from the instructor and student perspective, including assumptions about the students' motivation and barriers to empathic awareness.

After a certain period of crisis in the Seminar, the instructor stopped using feminist theory entirely in the course because their instructional team felt these concepts had been so fundamentally misunderstood by the students, according to a male secondary instructor:

> *i_5: ...we've even stopped using it in seminar. We try to explain that [feminist theory is] not about superiority, it's not about regaining. They have this very militant view of feminism. I don't know if this is from their parents. I kind of want to guess, but they almost see it as women are rising up to take over the man. I even said in class, "Guys, there's no other male story or story that's more male than rising up and taking over." So you know, they they're kindhearted I think, but if you put that kindness into a theory and challenge what they're doing, they get very defensive and just very uncomfortable. No matter how hard you try and say, "This isn't an agenda. It's just a discussion. It's not a damnation of you. It's just to talk about these issues. It's not pointing fingers.*

Although the students' experience in learning about feminist theory and gender inclusivity was almost uniformly uncomfortable, some students did report value in the experience. This portion of the Seminar course dealt with issues that were meant to be applicable to their Design Lab projects—expanding their notions of inequality and differing access based on gender and other forms of privilege:

> *s_1: And so it's a study of feminism and gender along with cultural stuff to take into account a lot of our projects because the main goal is to be able to think beyond or think outside of what you know and gain methods on how to think about that. And a few of the things they've shown us have really been impactful for me a little bit. It was just realizing biases and inequality and stuff and how stuff is separated unfairly in some situations.*

> *s_7: […] the idea is to think in a different mind frame instead of the one that we have right now. So instead of going into a problem with the mindset of a first-world problem we're trying to do a third-world problem like with the toilet project.*

> *s_7: So we can't take any of our ideals, necessarily, to solve the problem of a third-world country because they have a different set of opinions, different mindset. So we have to be able to change our mindset from the first-world into a third world or into one that's compatible with the third-world. So I understand the concept that they're doing feminism because it's such a drastic change and that we have to create a drastic change in ourselves in order to really fill the shoes of someone living a totally different life. So I completely understand why we're doing it.*

However, even though some of the students appeared to make a connection between feminist theory and the potential for marginalization with their Design Lab project, it still appeared relatively easy for the students to bracket aside any ill effects for women or other affected groups:

> *s_1: Oh, for us, the regions that are worked on, it's always women are just abused all around. […] It hasn't been able to affect our design, though, because the region we're going for is recovering, and there's certain roles that aren't affected via waste product kind of thing.*

Some of this transfer between feminist theory and readings on differences in bathroom practices was lost when translating from the largely Western context of their readings in Seminar and the developing context of their Design Lab project. Students were quite reflective on how this gap could be closed, with s_7 suggesting possible language the instructors could have used to better explain the connection:

> So an example would be if they had a reading one day, at least in the first couple of weeks, that was entirely about feminism to explain then, "We're not doing this solely so you know everything about feminism or so you solely know about this topic about feminism. We're doing this so you can understand a different point of view, which will help you with your toilet project. Understanding different points of views". Being so deliberate and literal in the first couple weeks so people can understand how to make that connection. Like they do a drawing of how it connects to the toilet project. And then after there it's up to them to connect everything afterwards. But allowing an example in the beginning for people who don't know how it would work.

Students were able to understand the learning gap, but were unable to close it without coordination between instructors and more substantial scaffolding of the theories they were learning about. Because the initial discussion of feminist theory in Seminar was so polarizing, it cut off the chance for these viewpoints to be used in a generative manner in Design Lab, while also potentially limiting students' interest in designing with gender inclusivity as a top priority.

Addressing Age and Gender in Bathroom Practices

This theme addresses the shifting mindset of the students as they realized the ways in which their designs were ill-equipped to address the needs of children and females, including the role that gender or height can play in patterns of use, safety, or inclusion for disabled persons. Due to the raised tensions from Seminar in regard to feminist theory and gender inclusivity, it is perhaps unsurprising that these issues were poorly addressed by students in Design Lab. One instructor explained:

> i_1: *I don't say that to blame the Seminar class, but [the students] were already primed to devalue anything that suggested anything about male privilege or male power, whether they realized they were doing that or not. And that is reflected in the entire...all of the designs for all of the projects. No discussion about menstruation. No discussion about the difference between sitting to urinate and standing to urinate, really.*

This lack of consideration of difference, whether it be in terms of female anatomy or the special needs of children or disabled persons, led to additional feedback in project critiques that was ignored and final projects that failed to address key issues of inclusivity. The Design Lab instructors used two primary strategies to build an awareness of the male biases of their designs: consideration of squatting, and the differing ergonomics of male and female anatomy; and a prototype test by a toddler, which foregrounded use of the toilets by children.

In order to visualize gender differences in a squatting position, the instructor, while discussing with one of the teams, asked male students to squat, and then other students who were there to look at the angle of their bodies. This stemmed from a previous conversation, where it was clear that the male students had assumed that everyone would squat in the same way, requiring an

identical solution for all users. Then, i_1 asked one of the female instructors to squat. Students from the group who originated the discussion, and others from surrounding groups, gathered around to watch. Observing students were then asked by the instructor to notice the angle on the female sex, and how it compares to the male sex. When visualizing the position being performed by individuals of both genders, students seemed to realize that differences exist, and the instructor asked them to consider this difference when finalizing their design. This strategy was repeated by the students, especially in the originating group, several times during the design development phase. i_1 reflected on this activity later, telling us: "*On the one hand, it helped them empathize with some part of the group because squatting and sitting are different. But it's impossible for me physically squatting to know what it's like for a woman to physically squat.*"

During another Design Lab session, the instructor invited the parents of a three-year-old child to bring their toddler to class so students could test their prototypes in a simulated use by a child. Three of the four groups were present during the day of the testing. During this event (Figure 2), students had a chance to talk to the child under the supervision of the parents, with some students more comfortable with this task than others.

Figure 2. Simulated use of a toilet prototype by a child during the testing phase.

The first group to approach the child did not seem to have much experience with young children. After prompting the child to choose the correct seat for solid feces, they realized that the drawings they had attached to each seat were not effective, as the child answered "*I don't know!*" The second group also had trouble communicating with the child. When asked to squat, it became clear that the child did not recognize the word. In an attempt to resolve this issue, the team leader for the second group simulated a squat position and asked the child: "*Can you go like this?*" The child immediately understood, and mimicked the position. However, he stood in the opposite direction of that intended by the designers. The team leader indicated that even though this was not what they expected, their design was flexible enough to be used by a child in that position. The test seems to have raised awareness for the students about some assumptions regarding the communicative ability of images and the differing ergonomics of a child in relation to their design.

Awareness of inclusivity and the differences in bathroom practices based on sex, gender, physical height, and capability were addressed to varying extents by the project teams. The group that used the squatting approach consistently did make significant alterations to their solution to allow for a greater range of use, even if their design failed to address other key aspects important to their context of use. It is striking how few students were aware of the differing anatomical considerations, and the impact that these considerations would have on the broad use of their solution. One student reflects on this experience, explaining their team's rationale for being more inclusive:

> s_7: *Before I started thinking of ideas of how to use [the toilet] and I didn't actually think of...Like I'm still a little ashamed to say I didn't think of a female counterpart exactly using it and how they might feel. Because with one design I did I had an...To be very crude about it an aiming system to where you sit down and there's one...There's one main chute for the fecal matter which is angled just slightly and then another chute that's angled for urine filtration and I didn't think of the female anatomy enough. And I realize it might be difficult for them to be relaxed and use the product as I would think about it. Which is why we actually switched to the two-hole system.*

Similarly, despite the time spent with the child, teams did not appear to modify their designs in any meaningful way, although the first team replaced the drawing of feces with another, showing a cartoon dog squatting to defecate. When this lack of consideration for children was brought up by reviewers during two of the groups' final presentations, the students explained that they hadn't really considered children in their design. In fact, one group admitted that their current prototype only worked for individuals weighing over 130 pounds, laughingly explaining that one of their group members was not heavy enough to trigger the flushing mechanism. Although they planned to remedy this through use of custom-built springs in the future, they estimated that the improved prototype would work for anyone over 30 pounds, and did not discuss how this might limit use by small children.

It appears that these two instructional strategies did succeed in raising the students' awareness of creating inclusive solutions, but this awareness did not consistently result in a final product that addressed the needs of all users within their use context.

Discussion

As we have detailed in the sections above, students engaged with, but often did not follow through on, their empathic connection with the target user population. While students conducted enough research to build a concrete understanding of the challenges their users faced in relation to sanitation, bringing their varied lived experiences, some including travel to developing regions, their fixation on technical challenges and limited culturally-inspired constraints produced a myopia that was difficult to overcome. While the Design Lab and Seminar experiences were intended to synergistically combine, informing the students' design activity, the barriers students erected to considering gender inclusivity and feminism in Seminar also appeared to serve as a coping mechanism for the chaos and uncertainty of their design project, facilitating their ability to ignore use-related issues (e.g., cultural appropriateness, gender inclusivity) in their design projects.

Next, we will discuss explicit barriers students faced in building their empathic ability through this project; then, we will contextualize these barriers within the identity formation crises students experienced during this semester, which inhibited their ability to gain and act on new perspectives.

Barriers to Empathic Development

Even though students had many tools at their disposal (both theoretical and practical), they frequently fell back on comfortable ways of looking at the design situation (e.g., through only their own perspective, or a fully technical view with no social embeddedness). The students' own comfort was a barrier to their development and enactment of empathy in this regard, with insights about their target use context being filtered through their own lived experience in a relatively egocentric way.

The instructional situation in the Seminar course also deepened existing areas of discomfort rather than providing students with a sense of agency and safety. Students cited the subject matter (particularly feminist theory), the gender of the primary instructor, and their perception that the instructor was unwilling to listen to their point of view as reasons for their discomfort and lack of engagement. While the end goal of this theoretical journey was well-intentioned, it left the students vulnerable and defensive, rather than ready to embrace contradictions and change their own design approach in Design Lab. It may be worth considering whether instructors providing this type of experience may need to more deeply analyze students' own culture and lived experience before and during such a course. Students who are self-proclaimed "technologists" may have not had sufficient experience engaging in the type of discourse encouraged, or the skills to read and effectively process the materials offered. As recommended by more than one student, more explicit linking of the material to their project may have been of great benefit to them, as would selecting materials that related more directly to the context of the design project. Explicit modeling of this behavior by instructors—showing students how to look for information in order to connect with people from different cultures—would have been beneficial in building awareness and demonstrating this cognitive skill.

McDonagh-Philp and Denton's notion of a student's *empathic horizon*[33] is one helpful way to analyze the students capability to build empathy with their end user. A empathic horizon can be defined as "the individual's range of understanding and empathy for user experiences in different contexts."[33] In this project cycle, the students' limited lived experience was a barrier to their development and performance of empathy, suppressing the range of their empathic horizon, and reinforcing an locus of social and cultural consciousness much closer to North America than their target region. Because of the complex nature of the project, students tended to immerse themselves in the technical challenges they felt they *could* control, rather than the social challenges that appeared more daunting and less familiar. The concepts that students were expected to address in relation to their chosen use contexts were also hard to manage from an emotional standpoint, requiring a level of metacognition to process and manage that many students did not yet possess; this indicates the importance of managing the emotional faculties of students[45] as well as their growth in technical skill.

Identity Formation at a Crossroads

This project found the students at a crossroads in their development of an engineer or technologist identity. The Design Lab and Seminar experiences in the previous year had encouraged the students to take on a user-centered/human-centered design philosophy, using materials from IDEO and the Stanford d.School to scaffold their understanding of basic design processes. For example, a Design Lab project from the students' freshman year required them to design a "garden-in-a-box" prototype that would reduce the effect of food deserts in large cities around the world, requiring attention to the unique needs of urban and non-Western users. Through projects of this scope, students had previously been exposed to the full design and development lifecycle. However, the students had not taken on an identity as a human-centered designer to the extent that they were focusing on their own empathic development as a primary normative commitment. Their identity was being shaped and performed primarily in a technological sense—with the ability to build, construct, and problem-solve outstripping any attempts of the instructional setting to encourage them to consider the end user and context. In this sense, they had to choose to fall back on the identity commitments that made them feel comfortable (e.g., technical ability) or to lean forward into the chaos and discomfort of designing for a user that was different in many ways from their own experience. The social complexity of the use context they were designing for was less manageable than the immediate technical challenges with which they were preoccupied, and the logistical plan for the semester-long project foregrounded technical milestones (e.g., initial prototype, bill-of-materials, final prototype) rather than the cultural specificity and appropriateness of their design.

From an observer perspective, it does appear that there was sufficient choice to be more empathic and human-centered, but from the student's perspective, they were not given sufficient tools to do so—particularly in an integrated way. Although the Design Lab instructors assumed these critical abilities and empathy would be developed within the Seminar experience, the lack of implicit trust and valuing of the students' own lived experience closed down their incorporation of empathy and feminist attitudes that had the potential to be generative to their design projects. This is potentially a case of unmanaged cognitive overload—where a perfect storm of a complex technical and social/cultural challenge in Design Lab met with an identity crisis generated by rethinking issues of privilege and gender in Seminar—leading students to pick the most objective, concrete path to completing their project.

This small-scale implementation of instructional techniques to encourage the development of empathy indicates some potential barriers to producing lasting change. While the theoretical framings of empathy and practical techniques to act on design concerns in relation to gender were available, their presentation led to a toxic environment where students felt unsafe, thus affecting students' ability to reflect on their understanding of gender inclusivity. This indicates the need to address the emotional wellbeing of students when introducing concepts that have the potential to threaten their understanding of themselves and others. Numerous students built a sophisticated cognitive understanding of their target user and context, but due to the complexity and emotional reaction of their Seminar experience, this cognitive understanding was not adequately translated into an emotional "feeling" on behalf of the user. While insights from research were included as constraints in final projects, they were often mechanical in nature— limiting scope without consideration of how multiple cultural issues might converge to invalidate a design solution that was only built with one constraint in mind. This indicates an empathic

process which moves from cognitive understanding to design action without an emotional awareness driving this translation.

Conclusion

While this study is limited in scope, both in the size of the student population and the unique nature of the transdisciplinary program, the student experiences we have reported indicate a need to understand the ways in which empathic development can result in identity conflict. Unlike other types of learning, where the content can be easily abstracted or bracketed away from our own existence, taking on a human-centered approach and actively considering the needs, desires, and conditions of others unlike ourselves can be deeply threatening to our own identity. The challenge is to encourage this sort of reflection on identity, while also allowing students a voice and sense of agency in managing this complex and chaotic period. This indicates that instruction must value the emotional attitudes of students towards ethical concerns, simultaneously pushing students to consider new perspectives, while also grounding these differences in positive terms that build upon their own agency and identity, rather than stripping this identity away in a whitewashing fashion. Our future research will continue to probe the causative factors that relate to empathic awareness and development, and the ways in which empathy relates to the ethical and moral development of engineering and technology students. Research from a critical perspective (e.g., feminist theory, care ethics, critical pedagogy) is needed to describe the array of factors that may affect the ability of a student to take on an empathic engineering identity, and the ways in which lived experience, belief systems, and understandings of the ethical content of design might limit the ability of a student to alter or transform their empathic ability.

Previous scholarship has suggested numerous paths for encouraging the ethical development of engineers and technologists. This study demonstrates the value of considering student agency alongside curricular reform. Raising the issue of ethics and empathic connection with users is only a first step towards producing real and lasting change in the student's philosophy of design activity. If the curriculum is intended to scaffold students' development of empathy beyond the informational stage, instructors must be prepared to engage with deep and complex emotions that can alternately push students to break down or become more resistant to changes in their design approach. Viewing ethical awareness as an imperative for the education of a developing engineer, this experience of confronting one's own limitations in empathizing on behalf of an unfamiliar user population should be broached early, encouraging students to rethink their own conceptions of self alongside their development of technical ability.

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