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Lessons Learned from Developing and Implementing a Community-Based Design-Abroad Project in Cartagena Colombia: Community Power, Resource Management and Student Learning

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Introduction

Community-based engineering design projects are a growing feature of engineering design education thought to support students' development of sociotechnical ways of thinking, knowing, and doing in engineering [1-2]. However, scholars have critiqued common approaches to community-based engineering design projects. First, while community-based engineering design projects often attempt to employ participatory design strategies designed to foster equitable participation for those historically excluded from engineering design processes [3], research on community-based engineering design project-based learning suggests these projects tend to be exploitative and extractive, often leaving community partner organizations and community members without the benefits of the projects [3-7]. Thus, there is a need for engineering design educators to rethink common approaches to developing and implementing community-based design projects in ways that elevate community members' knowledge, autonomy, and self-determination.

Still, while scholars might wish to elevate community autonomy and self-determination, the goal of these learning experiences is to foster sociotechnical learning outcomes for engineering students [8]. Engineering educators often describe the types of sociotechnical skills students should develop to implement effective community-based design processes. For example, Leydens and Lucena [8] describe listening contextually, identifying structural conditions, acknowledging political agency, mobilizing power, increasing opportunities and resources, reducing imposed risks and harms, and enhancing human capabilities as central cognitive and behavioral learning outcomes students should develop in community-based, sociotechnical engineering design education. Others point to frames of thinking about people and communities, such as asset-based (i.e., vs. deficit-based) thinking and reflexive engagement [7]. More still, others point to the need for paradigmatic shifts in the ways engineers learn about and engage with ethics education. For example, Devon and Van de Poel [10] argue for a "social ethics" paradigm, which centers "an examination of structure and process" and "involves social relations, their structure, and the norms and policies that characterize them" (p. 461).

Herein, we adopt the social ethics paradigm to examine and describe the process by which we developed and implemented a community-based engineering design partnership between a small, private American university and community partners in Cartagena, Colombia, herein referred to as the Engineering Design Abroad (EDA) project. To do so, we resist the common urge to analyze the design process through a micro-ethics lens that centers individual thinking and individual ethical decision making. Instead, we describe the nature and structure of social relationships both at the individual and collective levels, as well as the norms and policies, whether codified, explicit, or implied that governed the social arrangements for decision making [10]. In describing this project, we point to at least two necessities for fostering equitable

outcomes in community-based engineering design work–epistemological flexibility and administrative flexibility.

Project Background and Description

The EDA project was embedded in a semester-long engineering design, build, test, communicate course at a small, private, northeastern university. The goal of the course, and by extension the learning activities embedded in the project, was to foster students' sociotechnical design repertoires [21]. As a result, students were placed into teams and assigned to one of several semester-long community-based projects. For example, several teams worked with local area secondary schools to develop and implement robotics education programs. Other teams worked with a non-profit organization in the Navajo Nation to design water catchment systems [21]. The goal of each project was to apply frameworks for thinking about race/ethnicity, sex/gender/sexuality, (dis)ability, and other social systems (e.g., language, culture, sociopolitical context) in the context of a real-world engineering design project.

The project at the center of this practitioner-oriented paper entailed a partnership with community members in Cartagena, Colombia. We note that we have blinded the name of the community, as well as community members, to preserve confidentiality herein. The goal of the project was to position students to co-ideate, co-design, co-prototype, and co-evaluate design solutions with, not for, community partners. As a result, students developed interview protocols to foster information gathering with community partners, developed presentations to share their work and ideas with community partners, and, ultimately, travelled to Cartagena, Colombia to implement design solutions alongside community partners.

However, the goal of this practitioner-oriented paper is to not to examine students' behaviors and learning during the course component or travel abroad, though we draw on episodes involving students to illustrate broader points. Rather, our goal is to describe the process of developing the program, which entailed complex administrative processes, interpersonal communication, and cultural learning on the parts of faculty, administrators, and community partners. In what follows, we describe a series of supports and potential barriers we identified to the successful administration of the EDA project. We argue that the fact that this project occurred abroad entailed unique pedagogical, administrative, and educational activities necessary for supporting equitable student participation and learning.

Exploring and Negotiating Power Dynamics in the Program Design Process

Rolin (2009) describes social power dynamics as "the ability of an individual or a group to constrain the choices available to another individual or group" (p. 219). During the program development process, the ways that power dynamics–the abilities of various stakeholders to constrain the choices available to others involved in the program development process– we manifested became apparent. Herein, we describe three groups of stakeholders, namely, Tufts University global education administrators, community partners (i.e., individuals and groups in

Cartagena), and university faculty, and their respective abilities to constrain the choices of others in the program development process.

For example, the university faculty leader understood that students' participation in the community-based design project required community permissions. Moreover, in seeking to honor community autonomy, the faculty leader relied on community knowledge to make programming decisions, such as decisions about project goals, community involvement, and other context-sensitive decisions, which we visit in later sections. That is, community members had the ability to constrain pedagogical decision making, even if they had no intention or desire to exercise that power. Similarly, the faculty leader exercised power over the project parameters by delineating the appropriate financial and intellectual scope of the project for supporting students' learning. While community partners had ideas about the most appropriate scope of work, the university faculty leader still exercised power by constraining the scope of the project, both intellectually and financially, during the program development process. Finally, university administrators exercised power by delineating policies and practices for operation. That is, the university administrator could constrain community members' approaches to operating businesses by insisting they remain in compliance with institutional policies outside of the scope of their normal business practices, which we revisit in later sections.

To be clear, while the term "power" might evoke assumptions about sociopolitical dominance, we do not necessarily mean to suggest that individuals or group stakeholder exercised dominance over other individuals or groups of stakeholders. Rather, we found that acknowledging individual and collective power was an important first step to facilitating positive interpersonal relationships and interactions that supported the success of the programs. That is, it was important that global education administrators articulate institutional policies and practices necessary for successful operation, particularly when those policies and practices were outside of the cultural norms of community partners. Similarly, it was important that the faculty leader articulated learning goals to community partners to ensure appropriate scope and support for the project from the community. Finally, it was important that community partners articulated sociopolitical context to ensure that administrators and faculty understood and mitigated the social, political, and economic cost of the project to community members.

Thus, to successfully design and implement this project, we describe two necessities for fostering equitable outcomes in community-based engineering design work–epistemological flexibility and administrative flexibility–for each of the stakeholders.

Epistemic Flexibility in Engineering Design Thinking, Teaching, and Learning

Engineering design education is often taught around well-known engineering design process models. Engineering design models, which attempt to prescribe what must be done during the engineering design process, reflect a movement to improve engineering design practices through the development of systematic approaches to specific engineering design tasks [10-11]. However, existing research suggests that the development and implementation of these design process models has largely failed to impact engineering design practice both in educational

contexts, as well as in professional practice. For example, Maffin [12] notes that these models had not been widely adopted in industry, and though design process models, such as lean and agile methodologies, have subsequently come to prominence in engineering industry [13], existing research suggests that design process models are inadequate for community-based design.

We contend that one reason that design process models have failed to impact student and professional practice is due, in part, to the epistemic underpinnings of the models. That is, the desire to formalize the design process into neat, systematic steps or stages with objective, identifiable behaviors reflects a fundamentally Eurocentric view of the design process that strips design of its sociopolitical context. This criticism of existing design process models is not a theoretical one, but has practical implications for the ways students, faculty, and community members engage each other and the design process in community-based design projects. For example, both students and faculty, armed with prior conceptions of design process models, entered the design project with a seemingly straightforward, reasonable set of questions: What would the project entail? What is the budget and resources? Who will we be working with?

While students assume the answers to such questions are static, as they generally are in university-industry partnerships, projects, resources, and participants in community-based design projects are often dynamic, changing from day to day. Moreover, relegating the information gathering process to the beginning of the design process, as many design process models do, obscures the realities of design, particularly in community-based projects. Even those that capture information gathering as an ongoing process do not always capture the nuance that community autonomy plays in shaping students' design thinking *in situ.* For example, we often assume that the information gathered at Time C is a function of the information gathered at Time B, which itself is a function of the information gathered at Time A. However, in the EDA project, we quickly learned that such a conception of the design process was incompatible with the ethos of the project, which elevated community autonomy, as well as the active participation of community members, in problem definition, resource management, and decision making.

That the design goals, budgets, materials and supplies, or even the project itself, established at the beginning of a project are immutable was an unrealistic, but apparently widespread, expectation of students and faculty during the project. It occurred, for example, that students, faculty, and various community partners established a set of design goals, at which point students used resources to purchase materials and develop a systemic design plan. However, the sociopolitical realities of the community context resulted in changing design constraints, particularly as community permissions to implement design solutions changed from day-to-day or, perhaps, from hour-to-hour. When such changes occur, our well-trained approaches to engineering design became ill-suited for completing the community-based project, which we illustrate in the following vignette.

> Both students and faculty arrived in Cartagena understanding that our participation in the design project required community permissions which were tentative and changing.

However, after a series of interactions with community partners and faculty, students, at times armed with little more than loose paper and pencils, developed three new design projects related to garbage removal on Isla Barú: (a) A concrete stair structure along the side of a steep cliff to support manual garbage removal, (b) a pulley system with a carriage to support the mechanical removal of the garbage, (c) a shed structure for shelter from oppressive heat in Cartagena. The students, faculty, and community partners delegated each other materials and supplies for purchasing and spent the evening and following day gathering materials and supplies in preparation for the project. However, when the students and faculty arrived the next morning, and students determined that the shed structure would be easiest to tackle quickly, the group learned that some permissions had changed, and that the shed structure would no longer be a priority for the project.

Students expressed confusion and, to some extent, frustration at the lost time and sunken cost related to their initial plan. One student argued and reiterated their belief that the shed would be the simplest task, pointed at their design plan, and already purchased materials. It was only after considering discussions and cajoling that the student acknowledged that, though their plan had seemed appropriate and potentially successful, the project plan required changes in response to context-sensitive community permissions, as well as a desire to preserve community autonomy, self-definition, and self-determination.

Student and faculty expectations that the problem definition, as finalized during the initial meeting, would be immutable was clearly a faulty assumption. Indeed, students and faculty had not accounted for the real, dynamic, sociopolitical reality of the community context that shapes and reshapes the nature of projects, interpersonal relationships, decision making, and resource management. Students and faculty seemed to assume that community permissions, once given, were given in perpetuity. However, as the sociopolitical context changes, and permissions were withdrawn, it became necessary for students, faculty, and administrators to adjust their approach to the design process in order to preserve community autonomy, self-definition, and self-determination while also balancing student learning and adherence to administrative guidelines.

Thus, we suggest that both students, faculty, and administrators must learn a degree of epistemic flexibility when engaged in community-based engineering design work. By epistemic flexibility we mean to underscore both the utility and limitations of the design process models frequently taught in engineering education. That is, Sodian and Barchfeld [14] define cognitive flexibility as “the ability to form multiple representations of a given situation or task” that “facilitates flexibility in response to varying situational demands” (p. 141). We note that the desire to improve design practices by prescribing appropriate behaviors (i.e., in prescriptive design models) [10-11], mitigating waste (i.e., in lean methodologies) [15] or eliciting regular feedback and reflection (i.e., in the case of agile product development), are themselves reasonable and appropriate design goals. However, these goals must remain responsive to the sociopolitical realities of the design context, including the need to preserve community

autonomy, self-definition, and self-determination. Thus, students must be trained to resist the Eurocentric epistemic frame that prioritizes order and systemic processes over community-based knowledge and autonomy [16].

Administrative Flexibility

The need for administrative flexibility as an essential condition for our community-based engineering design work surfaced early during project planning and extended through the duration of the project. This type of flexibility was important not only in carrying out engineering design work, due to its iterative and ill-structured by nature [17-18], but also in maintaining a community-based approach that prioritized ongoing community involvement and leadership, such that community members' opinions, priorities, and decisions guided all of our work. It became clear, however, that operating from this perspective was difficult to manage within the norms of a university structure that was accustomed to functioning using a different knowledge base and cultural logics than community partners. Cultural logics [19-20] refer to a set of internalized principles that inform how individuals make decisions, which stem from lived experiences within specific cultural contexts. We suggest that when stakeholders–faculty, administrators, community partners–are guided by different cultural logics, even common goals can become difficult to attain.

For example, university administrators consistently demonstrated a set of priorities around student safety, legal protections, and effective operations–reasonable goals for those balancing program operation and institutional regulations. Though all project stakeholders also prioritized these elements, differences in knowledge and cultural logics related to operating procedures and interpersonal communication led the different stakeholders to define and act on these priorities differently, which we describe below.

> During discussions about student lodging in Cartagena, administrators advocated for selecting a hotel in Bocagrande--a Cartagena neighborhood with several well-known, international hotel chains. They were drawn to the style of operations these hotels use, with clearly defined contracts, predictable service, the ability to change rooms should maintenance issues arise, and options to reserve in advance and make modifications within a generous time frame. They also appreciated the relative safety and conveniences the Bocagrande neighborhood could offer to students, only a 25-minute walk or five-minute car ride from the city center.
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> Community partners voiced concerns about housing options in Bocagrande regarding the same set of priorities. They explained that although Bocagrande is physically located quite close to the city center, a 25-minute walk in oppressive heat during the day or night could pose serious health risks to students not used to the climate. Relatedly, what appears to be a five-minute drive on a mapping website can easily surpass 45 minutes due to seasonal traffic. Community partners noted that traffic and demand for taxis and rideshare vehicles during evenings and late nights could force students into situations where they may have difficulty returning home after visiting the historic city center during

evening free time, posing several safety risks. Traffic leaving a Bocagrande hotel in the morning could also double the already hour-long commute to the work site, sacrificing the priority of effective operating procedures by putting the overall feasibility of completing the project during the given timeline at substantial risk. Instead, partners advocated for a large home in the city center, where students could easily walk to a number of destinations to be a part of the vibrant local culture while also staying in a relatively safe area closer to the worksite. Renting an entire home, partners shared, would also provide common spaces where students could build relationships with one another and more easily collaborate on project ideas during the evenings.

University administrators acknowledged feedback from community partners about logistical issues and safety concerns, but raised other safety concerns, as well as budgetary, privacy, and liability concerns. For example, regarding the idea of renting a shared home, administrators raised concerns about legal liabilities and working within university procurement policies. Where hotels could easily accept credit cards, the same could not be said for the lodging options community partners suggested. Administrators also had questions about the nature of housing accommodations to support diverse student needs (e.g., floorplans, types of beds, room configurations) and contract questions and specifications, neither of which are typical conversations for clients to have with housing agencies. What, for example, would happen if unforeseen damage rendered the housing location uninhabitable? Whereas a larger hotel could more easily move students to a different set of rooms, this would likely be more challenging, if not impossible, with the housing sites recommended by the community partners. Understanding why administrators needed this information, while also understanding that these types of questions could offend representatives at the housing agency and damage relationships, community partners stepped in to facilitate compromises by communicating the needs of both parties. Through a series of discussions, community partners facilitated a compromise between administrators and the housing agency–the housing agency provided documentation that ensured their company was a legally registered entity with appropriate insurance coverage, as well as the ability to accept credit cards and other institutionally approved forms of payment. In providing these assurances, the administrators were able to better navigate institutional constraints so that the chosen housing site was aligned with cultural learning goals and project priorities, and the housing agency was able to receive payment in a format that worked for their needs.

This example highlights how, despite sharing a set of priorities, the different knowledge base and cultural logics each drew from shaped their approaches to meeting these priorities quite differently. Administrators' typical means for assessing student safety and effective operations relied on knowledge sources (e.g., safety reporting sources and mapping websites) that were not always aligned with the knowledge provided by community partners, which was based on their lived experiences. Thus, effective administration of the project required administrators to be flexible in their approaches to gathering and utilizing local knowledge in order to protect both priorities. Similarly, because community partners had not previously worked with a client like a

university entity, they had to be flexible to accommodate their particular legal and procurement needs, while drawing on cultural knowledge about how to voice these needs within boundaries of appropriate and respectful conversational norms in order to preserve relationships.

Discussion

One goal of this paper was to engage in reflexive practice about the development and implementation of the community-based engineering design abroad program in Cartagena, Colombia. In doing so, we engaged in individual and collective self-critique about role management, communication, resource management, and decision making throughout the development and implementation of the program. Our goal was not to establish a singular approach to developing such programs. Indeed, the very nature of the program required context-sensitive decision making and responsiveness to evolving sociopolitical issues. Rather, our goal was to reflect on the implications of these issues for students' learning experiences and learning outcomes in the program.

We argue that epistemological flexibility, in which students, faculty, administrators, and community partners remained open to different ways of thinking, knowing, and doing engineering design, as well as administrative flexibility, in which faculty, community partners, and administrators remained responsive to differing cultural logics around operating procedures across contexts, were critical to the success of the project. However, the impact of these decisions on student learning is the subject of ongoing analysis and future empirical research. Still, we contend that epistemological and administrative flexibility allows for students, faculty, community partners, and administrators to engage more fully in the development and implementation of the program, as well as the engineering design process itself.

Our future research will examine the types of learning experiences and activities that foster engineering students' sociotechnical repertoires for engaging community partners. While common research methods, such as pre-post survey designs and analysis of reflective activities, frequently suggest global education activities support important student outcomes, there is a dearth of literature detailing the types of learning activities that foster these outcomes. Our research will describe the varying program components of the EDA program, as well as the learning outcomes associated with each program component. Additionally, our future research will further examine the cultural logics of others involved in the project, such as community members, and the ways cultural logics shape community participation in the project.

Conclusion

Critiques of the ways engineering educators implement community-based design projects are widespread in the literature. However, this does not suggest engineering educators, practitioners, and administrators cannot possibly implement learning experiences that preserve community autonomy, self-definition, and self-determination while also fostering student participation and learning of important sociotechnical skills. We suggest that balancing these issues requires both epistemological and administrative flexibility–rethinking the epistemological

frames that guide engineering design process models and challenging cultural logics related to operating procedures. Integrating community knowledge into students' learning activities and administrative processes supported the success of the first iteration of the program. Our future research will examine how these decision-making structures influence students' experiences abroad, with implications for their learning experiences and outcomes *in situ*.

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