Engineering Education Graduate Student Researchers' Development as Scholars through Designing Culturally Sustaining Engineering Education Workshops with K-12 Educators and Students (Work in Progress)

Lise Clara Mabour, Tufts University

Clara Mabour is a second-year STEM Education Ph.D. student currently researching hip hop as a culturally sustaining method for teaching STEM. She has a bachelor's in environmental science from the University of Florida. Prior to starting her studies at Tufts, Clara taught high school science and research and she ran STEM and invention-focused afterschool programs and summer camps in South Florida. Her experience as a Haitian immigrant in South Florida has shaped her teaching approaches and research interests. Clara's research interests focus on the intersection of culture, learner agency, materials, and problem-solving in informal and formal K-12 STEM learning spaces.

Geling Xu, Tufts University

Geling (Jazz) Xu is a Ph.D. student in STEM Education at Tufts University and a research assistant at Tufts Center for Engineering Education and Outreach. She is interested in K-12 STEM education, makerspace, how kids use technology to solve real-world problems, AI education, robotics education, playful learning, and course design.

Mr. Brian Gravel, Tufts University

Dr. Gravel is an assistant professor of education and the Director of Elementary STEM Education at Tufts University.

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Abstract

This work-in-progress (WIP) seeks to explore the ways that two graduate student researchers conceive and refine design research practices with K-12 educators and students as part of engineering education research methodology repertoires. Graduate student researchers interested in K-12 engineering education engage with many knowledge sources, practices, and methodologies that inform how they design and conduct research and their future orientations in the discipline. Both graduate student researchers co-designed *with* the end user to develop projects or products [1]. Graduate student researchers in engineering education constantly design research studies, tools, and environments with their advisors, peers, and other researchers. However, opportunities to co-design engineering projects with learners and educators are less common for engineering education graduate students. Yet the work that graduate student researchers develop can influence K-12 educators and students and vice versa. Thus, graduate student researchers must have experience working with learners and educators during the research and design process to optimize the products/experiences they develop. More research is needed about how graduate student researchers develop their design-based research practices.

In this double autoethnography [2][3], we study how we, two engineering education graduate research assistants, refined how we designed culturally sustaining [4] engineering education workshops with K-12 educators and students. The data include notes from research design meetings, field notes of observations conducted in respective projects, and notes from conversations between the authors. We analyze how our conceptualizations of design-based research practices changed as we co-designed, iterated, and implemented our respective studies [5]. One study focused on K-12 teachers co-designing creative machine learning (ML) activities with researchers using novel technologies for a summer workshop. The second design-based study focused on hip-hop culture and practices as a culturally sustaining context to engage middle school youth in engineering and computational making [6]; researchers designed a summer workshop for middle schoolers with high school mentors. We have identified three preliminary themes within our shared experiences refining our design-based research methods: 1) we have taken multiple roles, 2) conversations with our participants and advisors are a tool for refinement, and 3) we build and learn to maintain a community around our work. As a key member in research groups and future researchers and educators of engineering education, more

information about how graduate students refine their concepts of research methods and practices, especially those designed with K-12 educators and students.

Introduction

This paper is a work in progress—In higher education, graduate research assistants are integral contributors to research. They spend their years developing as scholars and researchers who will go on to make contributions and potentially mentor other students toward the same trajectory. This work pays attention to the perspective of graduate student researchers as they refine their ideologies and practices with design-based research methods. This work provides assets as to how graduate researchers develop over time. We hope this work is part of a larger body of research where graduate students and professors will help dismantle hidden curricula to broaden the field and participation from underrepresented and historically excluded groups in higher education [7]. We also hope this work provides insights into how graduate students may think about their progression in learning, developing, and implementing new research methods in the field.

Doctoral candidates, particularly those from minoritized communities, face many challenges in their doctoral research journey. Lynch and Kuntz write about student's experiences and challenges in navigating the academic environment, emphasizing the personal and academic aspects of doctoral students' journey. Their work reveals the complexities and transformative learning that occur during the pursuit of a doctoral degree [8]. In this paper, we describe this complexity from the perspective of doctoral students. Graduate students can provide insights regarding graduate programs' inner workings that directly benefit their institutions' academic programs. For instance, analyzing the students' perspectives regarding courses, roles, and relationships with supervisors is essential for programs to improve best practices [9]. In our work, we consider how our relationships with supervisors/mentors can influence the ways we conceptualize our development as researchers and designers.

Graduate students are not just student researchers; they are developing faculty members and industry professionals. Thus, many autoethnographies regarding graduate students focus on their matriculation through a graduate program [10] and are outside the field of STEM/engineering education research or focus on their development as future faculty members. In their work, Maxey presents an autoethnography of their experience in a professional development program. Maxey uses narratives and shares that they feel free to explore critical topics as a graduate student, contrasting the ways that professors have to navigate the political landscape of academia. Additionally, they mention how graduate students' busy schedules, with coursework and research, make it difficult to find time for professional development [11]. The notions of freedom to explore difficult topics and the amount of time dedicated to research development are ideas we want to lean into for our work. During this exploratory phase of our development as future faculty and researchers, we assume multiple roles as researchers and try on many hats.

Since we allocate a significant portion of our time towards our research, we should understand how engineering education graduate students use that time to expand and refine our research methodologies.
While graduate students in STEM education have conducted autoethnographies to document their experiences, few have described their experiences in design-based research. One study looks at participatory action research (PAR), which involves close work with the research participants. The Author shares some of their decisions during their PAR study[7]. This work focuses on how the graduate student perceives this research method.

We discuss design research because it is the primary method we use at this stage in our research experience. As we learn new methods, our landscape for understanding the world of engineering education research may change. We seek to answer the following questions in our study: 1) In what ways do graduate engineering education students' ideas and practices around design-based research methods change, and 2) how do emerging scholars come to be? Design research as a methodology has a wide diversity of definitions. In this work, our use of design or design-based research coincides with crafting learning activities and environments intended to provide a need for a local community while producing experiences and artifacts that allow us to develop engineering education theory [12].

Methods

In this work, we borrow from aspects of autoethnography as a methodology for analyzing our self-reflections [13], video, survey responses, and field notes. We reviewed these data sources for evidence of refinement of practice and the ideology of engineering education graduate students and researchers. We borrow from aspects of autoethnography and thematic analysis. However, our analysis is broad at this stage. We use aspects of thematic analysis to look for common occurrences across our work and artifacts [14]. In this section, we will briefly describe each of the research studies we have done, the types of data we collected for this collaborative work, and our current process for analyzing our data sources.

Context

In the first year of our Engineering Education Ph.D. studies, we conducted design-based research studies that involved co-design elements. We attend a liberal arts institution, each with two Ph.D. advisors, have one advisor in common, and contribute to external research groups. We did two separate research studies with our respective research groups, the designs of which are detailed in the next section. In this work, we reflect on our individual experiences and identify common themes from our self-reflections and the data sources from our studies.

Study Designs

ML Activities Co-Design Workshop with K-12 Teachers: To refine our ML activities and better cater to students' needs, we organized a two-day (4 hours each day) virtual co-design workshop in April 2023, specifically involving K-12 educators. This workshop aimed to update and redesign the curriculum for upper elementary ML summer workshops with feedback from experienced educators. Five participants, all K-12 teachers specializing in STEM or gifted education, actively engaged in the collaborative design process. The overarching goals of the workshop were threefold: first, to gather reflections on the previous summer workshop from the teachers' perspective; second, to facilitate an exploration and understanding of emerging ML technology toolkits; and third, to collectively co-design ML activities tailored for the upcoming summer workshops.

Hip Hop + STEM Middle School Workshop: As part of the STEMCees research group, which designs and studies how hip hop as a culturally sustaining context to engage youth in engineering and computational making [8], we host a two-week hip hop + STEM workshop for 20 middle school aged youth. Before the workshop, we co-designed portions of the middle school workshop with high school youth, who also served as mentors to the middle school participants. Participants engaged in hip-hop-based activities and projects that allowed them to express themselves while using STEM skills like coding, computation, circuitry, designing, and many more.

Data Collection and Data Analysis

We use autoethnography and thematic analysis methods for this work [2][14]. We collected videos, audio recordings, and transcripts from our respective projects. Additionally, we collected field notes, personal reflections, personal narratives (written for a class assignment), and notes from our conversations about our self-reflections. Each of us identified data that reflected moments where we considered our refinement of practice or ideas and included a description of each data source. We reviewed each other’s data sources and descriptions, provided feedback, identified and highlighted key themes from the other’s work, and looked for common language and descriptions across the artifacts. When highlighting key themes, we looked for common themes, although neither author experienced all of the emergent themes. In this paper, we focus on the three most prominent shared themes identified in our reflections.

Findings

We identified three common themes in our analysis: 1) trying many roles: graduate student researcher, designer, learner, facilitator, and participant; 2) conversations and feedback as tools for refinement; and 3) building and engaging with communities.

1. **Trying many roles: graduate student researcher, designer, learner, facilitator, and participant**

As graduate students, we oscillate between various roles at any given time, but mostly, we are researchers and faculty in training. Doing design research also positions us as curriculum or study designers and sometimes participants in our research studies. The mentorship from our professors and more experienced colleagues is integral to our development.

Author 2	*"To be honest, during the whole co-design workshop, **I felt like a learner and a tester**, and I was not sure if the workshop could succeed even though I prepared a lot, got a lot of professors and colleagues' feedback, and help, I didn't have enough confidence with my first workshop."*

Author 1	*"This was my first research study as a graduate student researcher, and I was able to assume several roles during the co-design process. **As a learner in this space**, I gained insight from my research advisor and the young people we worked with."*

In their reflections, Authors 1 and 2 describe the roles they assumed during their first research studies. Author 2 describes how, initially, she assumed the role of a "learner and tester," with advisors and colleagues' help, she gained more confidence in her position as a researcher. Author 1 describes how she also used guidance from the youth participants as a learning experience. However, this could be seen as the merging of her role as a learner and her position as a researcher on a design-based research project where participant interactions mediate changes for new design iterations.

Author 2	*"When the workshop was completed, I finished everything I planned on time and got the data I wanted. Then, I got a very positive email with feedback from our [partner] organization. I finally feel I'm the designer of the workshop, and **I'm a real researcher now**."*

Author 2 describes feeling like a "real researcher" because she completed the research project goals by the assigned deadlines. She designed the study with edits from her research community and facilitated the ML co-design workshop by herself. She experienced some nervousness while leading her first study. However, the positive feedback from her research partners reinforced her confidence in her role as both a designer and a researcher. This is also implemented in conversation and feedback as tools for refinement.

2. **Conversation and feedback as tools for refinement**

Both authors describe how observations and conversations with participants and advisors have contributed to their understanding of different design and co-design techniques, and conversation is the more salient tool for refining design research ideas and practices. Additionally, conversation with others sometimes gives us access to information about people in ways we could not conceive.

Author 1	*"Though I thought the activity was fun, what was most important was recognizing that it was not fun for youth participants. So, we removed that activity from the list of daily tasks for the actual workshop. In hindsight, this change was necessary. Furthermore,* ***this was evidence of youth exercising their agency to say no to activities they did not enjoy. Co-designing with youth in this way means avoiding didactic practices and top-down dissemination of information and practice."***

Author 1 describes a situation where she had an activity planned that she assumed the youth would enjoy. She brought that design to the high school co-designers, and they expressed a strong dislike for the activity. They advised her to remove that activity from the planned activities for the middle schoolers. The open conversation with the high school mentors was necessary for her to reflect on why she wanted to include the activity and the aspects of the activity design that young people did not enjoy. This type of conversation was essential for producing reflexive, culturally relevant/ sustaining workshop designs. Author 1, had to rely on the high school mentors' knowledge and input because they are experts and participants in youth culture.

Author 2	*"To provide a more comfortable and safe environment for participants to share their ideas and thoughts, we told them all their ideas would be [anonymized post-workshop], and we don't judge any ideas, we just share and learn. To* ***encourage them to express more, we use a storytelling session instead of the traditional Q&A session to learn about participants' background experiences with AI/ML and their attitude/perspective of teaching AI/ML.*** *That was a successful attempt. Participants shared more than we expected with a variety of diverse experiences."*

Author 2's conversations with her participants were essential to creating an effective co-designing environment. Through feedback from research advisors, she learned the use of storytelling as a method for engaging the teacher co-designers in providing feedback regarding the workshop and the designed lessons. Conversations can look different; they do not have to be traditional interviews or focus groups. Storytelling provided more information than Author 2 expected, making it a method she is more likely to use in future workshops.

3. Building and Engaging with Communities

Co-design requires engagement with research participants and their local communities to address community needs [12]. Creating an environment that uplifts the contributions of non-researchers, co-designers, or research participants is an aspect of design that grad students need to engage with. Interpersonal interactions with youth co-designers made them feel safe enough to share ideas and provide feedback on the activities and the duration of tasks. The co-designing deconstructs the existing power structure that places youth at the bottom rung and allows them to engage deeply in the formation of activities and tasks suited to their interests.

Author 1	"My research advisor has a long history of working in the makerspace and the school district – he has long-lasting connections – **I was able to gain insight into how to establish secure and positive relationships with community-based participants, school district staff, and youth parents [in the school district].**"

Design-based research is intended to develop theory and to "impact" the local community by addressing "immediate participant needs" [12]—part of developing as a researcher is learning to cultivate and maintain positive long-term relationships with research communities. Author 1's advisor imparts knowledge about relationship building with community members and engages her in expanding her research community this way. While her project intends to identify how youth engage in computational making through self-expressive hip-hop and engineering education, she considers ways to embed beneficial activities for learners and position this work as a benefit for youth in the local community. Below, Author 2 describes the next stages of working with the educators and also considers the ways that teacher participants may benefit from the co-design workshop as preparation for the future workshop they will lead.

Author 2	"Half of the participants will teach the upcoming summer workshop. They will use the emerging ML tools, Smart Motors, and **teach the activities they designed in this co-design workshop**."

Here, Author 2 shares that the next stage of her work is when the teachers (co-designers) in this workshop become facilitators for an ML workshop with elementary and middle school-age learners. During this workshop, all participants developed a community of practice [15] around the tools and activities they planned. Additionally, as part of their design, Author 2 used the co-design workshop to prepare the teachers to facilitate the upcoming ML learning workshops. In this role, the educators and Author 2 will co-collaborate again as they expand their community to include young learners.

Discussion

Despite their significant presence within the research community, existing research often overlooks the valuable perspective of graduate students as researchers. Our first research projects do not bind our trajectory as researchers, but they bolster our pathways with the new methods and practices we've learned that serve as part of our repertoires as researchers and designers. We hope that by sharing our experiences, we can contribute our perspective and add insights into how engineering education graduate student researchers come to be.

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