

Board 261: Engineering Technology, Anthropology, and Business: Reflections of Graduate Student Researchers in the Pursuit of Transdisciplinary Learning

Deana Lucas, Purdue University, West Lafayette
Rebecca Martinez, Purdue Polytechnic Graduate Programs

Engineering Technology, Anthropology, and Business: Reflections of Graduate Student Researchers in the Pursuit of Transdisciplinary Learning

Abstract

Two graduate student researchers, with specializations in engineering and technology education and anthropology, collaborated on a National Science Foundation (NSF)-funded project on transdisciplinary education, known as the M3 (mission, meaning and making) project. The research project aimed to understand the transformative potential of transdisciplinary approaches in undergraduate education through a cross-college co-teaching model encompassing disciplines such as engineering technology, anthropology, and business. Over three years, data was collected and analyzed through interviews with over 100 students, faculty, and administrators. During the NSF project research, graduate student researchers discovered that their endeavors not only signify an added value to the research but also embodied the convergence of diverse disciplines. This convergence is vital for reshaping traditional higher education paradigms, echoing the mirroring the foundational philosophy of the project. Employing a collaborative autoethnographic (CAE) method utilizing data gathered by graduate researchers, this paper illuminates the transformative capacity of transdisciplinary collaboration within academia, surpassing the intended scope of the M3 project. The methodological approach emphasizes reflexivity and collaborative inquiry, mirroring the transdisciplinary spirit the M3 project seeks to promote. By intertwining distinct disciplinary perspectives, the graduate student researchers navigated the complexities of the research. This process allowed the graduate student researchers to uncover how our personal and professional experiences within the project exemplify the broader objectives and challenges of transdisciplinary education.

In this paper, key findings showed that motivations and lived experiences in the transdisciplinary research project are shared among graduate researchers. The findings contribute to a deeper understanding of the conditions under which transdisciplinary education can flourish, including the importance of mentorship, the influence of personal identities and interests, and the exposure to novel pedagogical approaches. Ultimately, the paper underscores the value of collaborative autoethnography (CAE) as a methodological tool in transdisciplinary research, offering a process-oriented perspective that enriches the comprehension of transdisciplinary education's transformative potential. In summary, the collaborative journey of the graduate student researchers within the M3 project shows the transformations that can occur from cross-college co-teaching for transdisciplinarity undergraduate education.

Introduction

Integrating engineering technology, anthropology, and business, the M3 (mission, meaning and making) project creates active transdisciplinary learning experiences to transform traditional siloed higher education. It uses a cross-college co-teaching model, uniting varied disciplinary expertise. This collaboration seeks not only to broaden disciplinary influence but also to advance the educational mission of higher education and spark innovation. Funded by NSF, this three-year project involves a collaboration between the Polytechnic School, College of

Liberal Arts, and School of Business. The projects' focus was on developing a scalable transdisciplinary model for innovation-focused undergraduate learning.

The M3 project aims to equip undergraduate students with the ability to understand the **Meaning** behind the societal issues, to foster a sense of **Mission** in addressing these challenges to make positive impacts on people and communities, and for **Making** solutions that cater to the unique strengths of the disciplines. The model fosters transdisciplinary collaboration by crossing academic boundaries, featuring co-teaching from instructors and co-learning among students from diverse majors and backgrounds. A vital feature of the program is collaboration among diverse academic units to develop courses, utilizing the making and doing from engineering and technology, the human and cultural interface of social sciences, and the business perspectives of entrepreneurship.

The project used a design-based research approach to create, test, and refine the curriculum, alongside ethnographic methods to examine university change processes to establish the model. Interviews were conducted with current students and alumni of the courses, faculty, and administrators of the colleges to gather insights. Midway through the three-year project, the external evaluator for the NSF project underscored the crucial value of having graduate researchers from various colleges working on this project- highlighting their role in driving the transformation of higher education towards transdisciplinarity. As two graduate researchers—one specializing in engineering and technology education and the other in anthropology, taking a closer look at their perspectives provides valuable insights into the dynamics of cross-disciplinary teams. Their involvement not only supports the project's immediate goals but also enriches the broader objective of transforming undergraduate education. The interaction between different disciplinary approaches extends the project's impact beyond the initial objectives, offering a compelling case for the benefits of cross-disciplinary collaboration in academic research and curriculum development.

The initial M3 objectives were based on answering calls for transforming undergraduate education guided by the following driving philosophy: 1) everyone can be an innovator, regardless of their background or interests, 2) impactful innovation does not happen in disciplinary silos along, and 3) teaching in a different, more collaborative way. Prior research within the M3 project looked at how the transformation was occurring within institutions from traditional siloed undergraduate learning experiences into cross-disciplinary learning experiences and faculty transformation. Which was done through cross-disciplinary collaboration which brought individuals who span disciplinary backgrounds together to obtain diverse knowledge. Using various disciplinary expertise, the team analyzed the data. This approach assisted in understanding if/how transdisciplinary education could work at a large public research institution. The research team used multiple methods: interview data, ethnographic data, and student survey results. Collaboration was a big part of this project, however, disciplinary "modes of being" influence the M3 team members, because the disciplinary background of team members becomes a piece of who they are as scholars [1]. Hence, as graduate researchers became involved in the project, the cross-disciplinary interactions expanded to include them, thereby their contributions advanced the project's comprehension. However, how the graduate

student researchers found themselves in the project and choosing to pursue further action within the M3 project team, could shed light on the value of transdisciplinary ventures that encompass cross-disciplinary interactions among stakeholders.

Transdisciplinary ventures transcend the boundaries of traditionally siloed subject matter and can cultivate the skills of students to help navigate the multifaceted challenges of the world [2]. Within this paper, the graduate student researchers leveraged their collective expertise, positioned at the intersection of student and researcher roles, to envision collaborative co-teaching, group learning, and student inclusion from fresh perspectives. This is important because it demonstrates the unique perspective that graduate student researchers can bring to educational initiatives. By being both students themselves and actively involved in research, they have firsthand experience with the challenges and opportunities present in higher education settings. This dual role allows them to offer insights and ideas that may not be readily apparent to faculty members or administrators who are not as closely connected to the student experience. Therefore, understanding graduate student pathways that have led to want to contribute to projects like the M3 project, can lead to more innovative and effective approaches to collaborative research and education projects. This can be valuable as not all research is inclusive of graduate students' perspectives, even though their roles contribute to the broader understanding of research projects. Collaboration among the graduate student researchers commenced on data collection and analysis, as a crucial aspect of this project involves gathering and utilizing stakeholder data from students, alumni, faculty, and administrators. The utilization of cross-disciplinary expertise and backgrounds empowers graduate student researchers to bridge disciplinary knowledge by contributing their understanding of the data to the broader research initiative and team. Therefore, our goal of this paper is to highlight the journeys and experiences of graduate students engaged in a cross-disciplinary research team and how that ties into transdisciplinary learning.

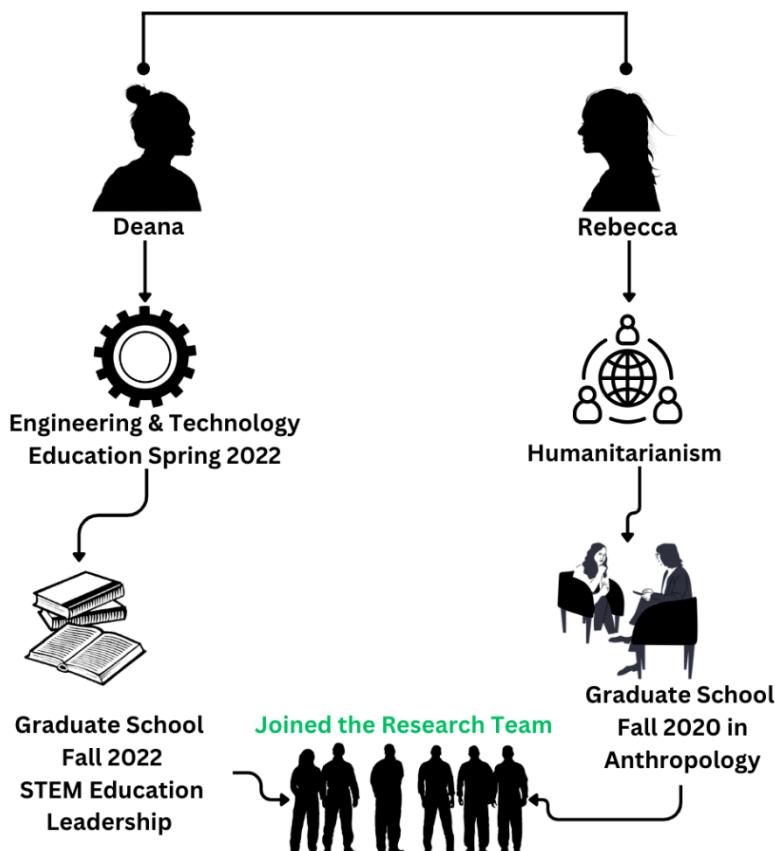
Consequently, understanding the experiences of graduate student researchers collaborating with faculty from diverse disciplinary backgrounds, all of whom are participating in this research initiative, can offer insights into the graduate student perspective when disciplinary lines are blurred. Due to the experimental nature of the M3 project and transdisciplinarity, the known information around how and why graduate students operate in the cross-disciplinary space is rather unexplored. As noted in [1], there's a scarcity of studies focusing on graduate students working in transdisciplinary environments. The M3 research team demonstrates collaboration through forging partnerships across academic disciplines and fostering a community dedicated to advancing education. Throughout the progression of the M3 research project, both graduate student researchers and faculty gathered, analyzed, and disseminated data. While graduate students can be seen as cogs in the broader machinery of the research project, we, as graduate student researchers, do wield influence over the project's outcomes.

We leveraged our diverse disciplinary backgrounds and lived experiences to make meaningful contributions to this initiative. This paper illustrates how our unique perspectives positioned us to enrich the project's outcomes. Through a collaborative autoethnography, we

documented our individual journeys and insights, shedding light on our collective experiences. Our findings, particularly concerning the use of collaboration and supportive with tools like NVivo Teams and Microsoft Teams, played a crucial role in refining the project's iterative research design and shaping its outcomes. Furthermore, by actively engaging in project meetings, educational community events, and data review sessions our process was further fortified. These experiences highlighted the transformative potential of transdisciplinarity in fostering collaboration across academic colleges. As we reflected on these experiences, we recognized the profound impact on our own scholarly trajectories, setting us on a trajectory toward becoming transdisciplinary scholars. This work not only contributes to the broader academic discourse but also lays a foundational framework for our future endeavors, preparing us for careers as scholars who bridge disciplinary boundaries.

This study focused on a master's and a doctoral student, as depicted in Figure 1 below. Our backgrounds vary, encompassing diverse bachelor's programs from different institutions and distinct paths to graduate school that led to participation in the transdisciplinary education research project.

Figure 1. Deana and Rebecca's Pathways to Transdisciplinary Research



Background

The concept of transdisciplinarity, initially championed by Jean Piaget and Erich Jantsch in the 1960s-1970s, challenges conventional notions of learning as a mere accumulation of

isolated experiences [3-4]. Instead, they proposed organizing knowledge into coherent sequences to foster enhanced development and education. Despite this, undergraduate education often remains compartmentalized within distinct colleges and departments [5]. This setup may leave many students without the structured transdisciplinary educational environments necessary for addressing real-world issues requiring innovation. However, universities, acting as central hubs, can provide the resources needed for students to engage in innovative practices aligned with their interests. The M3 initiative exemplifies this by extending transdisciplinary opportunities to undergraduate and graduate students alike through a broader research team [5]. While collaborations across various sectors are increasingly common, it's crucial to note that not all collaborations within higher education qualify as transdisciplinary; genuine transdisciplinary efforts involve a fusion of methodologies and frameworks transcending traditional disciplinary boundaries [6]. Moreover, transdisciplinary teams vary significantly in goals, disciplines, size, and other factors, lacking a standardized template [6-7]. However, this transdisciplinary team, as described previously, integrates the Polytechnic School, College of Liberal Arts, and School of Business. Faculty and graduate students make up the core of the research team.

The decision of graduate students to embark on transdisciplinary projects represents a distinctive aspect of their academic journey. In doing so, these students find themselves situated at a unique intersection, where various pathways, projects, and training converge, enabling them to transcend conventional disciplinary boundaries [1]. This dynamic presents a heightened level of complexity, particularly evident in research endeavors that span multiple frameworks. Within such multifaceted projects, graduate students are tasked not only with navigating diverse disciplinary perspectives but also with crafting and solidifying their own research and scholarly identities amidst this intricate landscape. Despite the increasing recognition of the value of cross-disciplinary training, a significant gap persists in our understanding of graduate students' experiences within transdisciplinary education research teams [1]. Closing this gap is essential for providing comprehensive support and guidance to graduate students as they navigate the challenges and opportunities inherent in transdisciplinary scholarship. Understanding the dynamics within transdisciplinary research teams is crucial, given that approximately fifty percent of collaborations within higher education fail when crossing college boundaries [8]. Successful transdisciplinary teamwork requires individuals with characteristics such as creativity, openness to learning, good communication skills, flexibility, and adaptability [6], [9-10]. In essence, gaining a deeper understanding of graduate students' roles within transdisciplinary research teams not only enriches scholarly discourse but also equips future researchers with the skills and insights necessary to thrive in collaborative, boundary-spanning academic environments.

Moreover, exploring the transformative impact of transdisciplinary work on individual practices is crucial [11]. While experienced researchers often align closely with their specialized disciplines, emerging researchers may exhibit greater openness to embracing transdisciplinary identities [1]. Therefore, this paper aims to contribute to the literature on graduate student experiences within cross-disciplinary research teams dedicated to transforming undergraduate education through transdisciplinary learning. By introspectively reflecting on our experiences

and collaborative practices as graduate students, we hope to deepen understanding of the evolving landscape of cross-disciplinary engagement in academia.

Methodology

This study aimed to elucidate the roles of graduate student researchers in collaborative cross-disciplinary endeavors supporting transdisciplinary learning. The importance of the individuality of each auto-ethnographer and what that can contribute to the research, as well as each researcher's perception of their experience is worth detailing [12]. Consequently, this study adopts the methodology of Collaborative Autoethnography (CAE), allowing us to switch to personal pronouns to discuss our experiences [12]. By adopting a collaborative auto-ethnographic methodology, we aim to depict subjectivity, emotion, and the influence of our individual experiences on the research process [12]. This approach allows for the exploration of two distinct perspectives on a shared project, highlighting the significance of individuality in shaping research outcomes [13]. To ensure the expression of our voices and stories, we responded to questions regarding our collaboration on this cross-disciplinary research project [14]. Recognizing the diversity of our individual paths, our objective was to unveil distinct perspectives that collectively shape the narrative of our collaborative autoethnographic inquiry [13]. Drawing on the rich tradition of anthropological reflexivity and autobiography, as well as the burgeoning practice of collaborative autoethnography, we engaged in a qualitative inquiry to explore our experiences collaborating on the M3 project [15]. We employed CAE, a qualitative research approach that is simultaneously collaborative, autobiographical, and ethnographic, to understand how our collaboration contributed to our programmatic, professional, and scholarly development [15-16].

In this CAE approach, we served the dual role of both researchers and participants, exploring our experiences through self-reflexivity and the multi-subjectivity of collaboration. Our dialogues served as positionalities, capturing the nuances of our experiences and interactions within the research context. Data collection involved 5 open ended questions developed collaboratively, ensuring input and approval from team members [16]. In CAE, each participant contributes their unique perspective to the collective work, maintaining their distinct and independent voice [15]. However, the amalgamation of these diverse voices within CAE fosters a synergistic and harmonious exploration of social phenomena, surpassing what auto ethnographers can achieve in solitary endeavors [15]. Within CAE, researchers have the flexibility to switch between collaborative group work and individual solo work [15]. This alternating approach enriches the collective work by adding depth and texture. During group sessions, individual voices undergo close examination within the community, benefiting from others' questioning and probing, which enhances the personal interrogation process [15]. Subsequently, researchers retreat to engage in individual meaning-making, honing their contributions. The goal of CAE is to move away from the idea that the research and the researcher(s) are separate, fostering new connections with the research project, and beyond [15].

Hence, CAE emerged as the conduit through which we, as graduate student researchers hailing from diverse disciplinary backgrounds, delved into the intricacies of our involvement within the transdisciplinary research endeavor. By adopting CAE, we embarked on a journey that not only facilitated the exploration of our individual experiences but also allowed for the

synthesis of our collective insights, thus offering a nuanced understanding of our collaborative engagement. Moreover, CAE served as a transformative process, enabling us to forge connections, propel scholarly inquiry forward, and assume agency within the dynamic landscape of our social context [15]. Furthermore, CAE is a “process whereby we have been able to create community, advance scholarship, and become empowered within our social context.” [15] (p.36). The statement underscores the significance of CAE as more than just a research methodology; it represents a transformative process with implications. The ability of CAE to foster community is crucial in research settings where collaboration is paramount. By engaging in collaborative reflection and dialogue, participants not only share their experiences but also develop a sense of camaraderie and mutual support. This sense of community fosters an environment conducive to innovation, knowledge exchange, and emotional solidarity, enhancing the overall research experience [15]. Through the intersection of personal narratives and scholarly analysis, CAE allows for the exploration of complex phenomena from multiple perspectives. This approach not only enriches the depth of understanding but also opens avenues for new research questions and methodologies. By embracing subjectivity and reflexivity, CAE challenges traditional research paradigms, paving the way for more inclusive and nuanced scholarship. Finally, by providing a platform for self-expression and validation, CAE enables researchers to reclaim their narratives and assert their agency. This empowerment extends beyond the confines of academia, empowering participants to advocate for social change and challenge dominant narratives. In essence, CAE not only contributes to the advancement of scholarship but also empowers individuals to navigate and shape their social reality, making it a vital tool for both academic inquiry and social transformation [15-16].

Therefore, the methodology outlined above, data collection and analysis encompassed both individual and collaborative efforts. This involved us working independently and in group settings. We both were involved in the analysis process. We worked together to pull codes and themes from our responses foregrounded individual and group meaning making to learn from our group experiences and ensure that both common and outlying individual experiences were included in our interpretations and understanding [16].

Utilizing the prescribed methodology, our approach to data collection and analysis seamlessly blended individual endeavors with collaborative undertakings. We engaged both independently and together, ensuring a comprehensive analysis [16]. Together, we meticulously extracted themes from our data, prioritizing the exploration of both individual and collective perspectives. This facilitated a deep understanding of our group dynamics while ensuring the incorporation of diverse individual experiences into our interpretations [15].

In summary, this study has endeavored to shed light on the multifaceted roles of graduate student researchers within collaborative transdisciplinary ventures aimed at fostering transdisciplinary learning. By embracing CAE, we have utilized a methodology that allows for the exploration of our individual experiences and perceptions, highlighting the richness and diversity of our contributions to the research process. Through the intertwining of personal narratives and collaborative inquiry, we have strived to capture the essence of our collective journey on the M3 project. Our adoption of CAE not only underscores the importance of individuality in shaping research outcomes but also underscores the transformative power of collaborative engagement in illuminating complex social phenomena. Through a blend of

individual introspection and collective dialogue, we have brought together insights that deepen our understanding of our collaborative efforts and contribute to the broader discourse on collaborative research methodologies.

Findings

1. Motivations

Both of us who took part in the CAE have different disciplinary backgrounds and life experiences. Deana is a second-year master's student focusing on STEM (science, technology, engineering, mathematics) Education Leadership. She has recently finished up her master's program and will be continuing her education in a Ph.D. program in Technology. She has a Bachelor of Science degree in Technology and Engineering Education. Her training consisted of pre-service teacher training, where she worked on projects around pedagogy for engineering and technology education and worked with/taught machinery to execute designs. Her experiences have been filled with hands-on learning opportunities, and she hopes to provide her future students with similar learning opportunities. Deana is a graduate researcher on the M3 project, with Rebecca who's introduced in the following paragraph.

Rebecca is a second-year PhD student, a soon-to-be candidate interested in collaborative approaches to making and sustaining educational spaces. She spent nearly ten years working in international non-profits and social services before coming to graduate school. She has a passion for cause-based or mission-driven pursuits in education and health, with a particular interest in women's leadership and development. Her undergraduate degree was in international business before pursuing roles in the humanitarian sector. She brings together her interests and expertise to think about pursuits of social change within higher education.

1.1 Support Transdisciplinary Learning

As we delve into our motivations around our involvement in such a team, it becomes evident that our aspirations converge around a shared commitment to fostering transdisciplinary learning experiences. Across our responses to prompts regarding our motivations, a common thread emerged around a desire to advance transdisciplinary experiences for students and to contribute to and learn from collaborative endeavors that transcend disciplinary boundaries, as seen below:

Deana

"After a little time working with the people in this research group, I realized that it was a combination of my passion and my skills. I was learning how different disciplines can interact to provide students with meaningful learning experiences. I think my passion for hands-on, active learning and education led me to want to learn more about how to make these experiences come to fruition for more students. I wanted more students to experience innovating with a team and designing prototypes. All forms of education are powerful, but learning and creating with people

from various disciplinary backgrounds can make innovative and necessary products or outcomes. People with different academic training look at the world using different lenses and applying that to a cross-disciplinary design team seems like it could and has led to innovation. This project provided me with new educational tools by allowing me to witness the value of converging disciplines."

Rebecca

"Pursuing graduate school was primarily driven by my eagerness to explore how various disciplines and sectors collaboratively tackle global development challenges. So, when an opportunity to engage in the project that epitomized this interdisciplinary approach emerged – specifically, training students in human-centered design – I was immediately drawn to it. My commitment to the mission of the project was what drew me in, and I was excited at the opportunity to learn from professors who do the work I hoped to do someday."

Our shared commitment to support transdisciplinary learning is evident in both our motivations for participating in the research team. Deana emphasized her passion for hands-on, active learning and education, expressing a desire to explore how different disciplines can collaborate to provide students with meaningful and innovative learning experiences. She sees the power of diverse perspectives in creating valuable educational outcomes. Similarly, Rebecca's eagerness to explore how various disciplines collaboratively tackle global development challenges aligns with the project's interdisciplinary approach, particularly in training students in human-centered design. Our collective experiences reflect an enthusiasm for the project's goal of delivering transdisciplinary experiences for students. Both of us highlight the importance of learning from individuals with diverse backgrounds within the project, emphasizing the value of cross-disciplinary insights. The focus on benefiting students and placing them at the core of the research project further underscores our shared motivation to contribute to and learn from a collaborative and transdisciplinary environment.

1.2 Personal Connection to the Project

The convergence of personal passions and professional pursuits often sparks a sense of purpose and drive. Such was the case for us, whose individual journeys and experiences converged with the goals of a transdisciplinary research project. As we embark on this exploration of our contributions, it became evident that our involvement in the project was more than just a professional obligation—it was a personal connection rooted in our past experiences and aspirations.

Deana

"I had the opportunity to participate in a Mentored Undergraduate Summer Experience (MUSE), where I took part in learning about research with a mentor from my bachelor's program. During this experience, I sat in on a fellows meeting that was part of a research project that included STEM educators nationwide. I remember sitting and watching my professor/mentor talk to the

other fellows on the call. Looking back, I remember being so confused by the jargon and finding myself wanting to be a part of the conversation. When I first came to graduate school and found that I would be involved in this project that focused on transforming undergraduate education to provide students with authentic learning experiences through the convergence of disciplines, I was excited but unaware of what it fully encompassed. However, after a little time working with the people who are part of this research group, I was able to immerse myself in the world of research and found that it was something I enjoyed. I liked being a part of the conversation that I witnessed during my undergraduate experience. I was learning about how different disciplines can interact to provide students with meaningful learning experiences that transcend the boundaries of disciplines."

Rebecca

"My previous career in international development and the non-profit sector spanned several years, during which I consistently recognized the need for a multifaceted approach to address complex issues, such as in cases that I worked on in community health and education. To me, the application of an anthropological perspective is crucial here. Anthropology, with its rich understanding of human behaviors, societal dynamics, and the interplay between local and global contexts, offers invaluable insights."

We share a personal connection to the project that stems from our individual experiences and passions. Deana's involvement in a Mentored Undergraduate Summer Experience (MUSE) exposed her to a research project involving STEM educators, sparking her desire to contribute to education. Rebecca, drawing from her career in international development and the non-profit sector, recognizes the importance of a multifaceted approach informed by anthropology. Our past experiences converge with the research project's goals, creating a shared enthusiasm for transforming undergraduate education through the convergence of disciplines. The project provides a platform for Deana to engage in meaningful discussions and for Rebecca to apply her anthropological perspective to address societal issues, aligning with our respective passions and skills.

2. Strengths of our Roles

As graduate students, we find ourselves a part of a more significant project. We are working on a cross-disciplinary research team that involves many stakeholders and five faculty members who guide the project. We work alongside these people in various meetings and throughout our days, whether in official meeting time or casual conversations. Below, we depict our roles and the strengths we bring to a cross-disciplinary research team as graduate students.

2.1 Our Backgrounds

Within any collaborative research endeavor, the amalgamation of diverse perspectives and skill sets enriches the depth and breadth of inquiry, offering unique insights and approaches. As showcased, each of us brings to the table a distinctive set of strengths and perspectives that

contribute to the collective understanding of the research project. While our perceptions of contribution may differ, our shared commitment to advancing the research project underscores the inherent value of embracing diverse viewpoints within the research team dynamic. Through our complementary strengths and shared dedication, we exemplify the transformative power of collaboration in driving forward academic inquiry and innovation.

Deana

"I believe that my contribution to the project goes beyond participation. I believe I bring with me a technological and engineering education mindset that adds to the way we as a team approach ideas. From my perspective, the additional perspective of technology and engineering adds a different lens for problem-solving and innovation. This lens has been used for writing papers, adding ideas to conversations, and a different way to look at data. All the ideas, being welcomed by the research team, and getting constructive feedback to improve the ideas to reflect the greater goals of the M3 project."

Rebecca

"One of my greatest strengths I believe as an anthropologist is my keen ability to observe and highlight nuances often overlooked in research inquiries or projects. Anthropology, with its diverse range of skills, theories, and focuses, equips me, particularly as a cultural anthropologist, to be acutely aware of the sociocultural elements embedded in pretty much everything. In this project, I felt my anthropological lens was helpful in discerning key insights during interviews with students and faculty. These insights were crucial in understanding the project's successes and the challenges. For instance, I noticed a distinct sense of belonging emerge from the data among participants in our program, differing notably from students' experiences in other campus programs. In a large institution like ours, this aspect is significant not only for student retention and positive learning experiences but also influences what students pursue post-graduation and how they reflect on their higher education journey. I firmly believe that more experiences like this should be available to students, particularly undergraduates. I know I would have loved them as an undergraduate and see the potential from my professional experience."

While our perceptions of what we bring to the research team dynamic differ, the inherent value of the different perspectives goes beyond how we define our value. However, we lean into the sides that we know we can do well and use that to engage in the rhetoric around this research project to add to the progress. We bring unique and complementary strengths to the project, as detailed above. Deana sees her contribution as enhancing the team's problem-solving capacity and aiding in fostering innovation. Her perspective aims to leverage her background to add value to the overall team dynamic. On the other hand, Rebecca, an anthropologist, excels in observing and highlighting nuances often overlooked in research. Her anthropological lens, particularly on sociocultural elements, was invaluable in discerning key insights during interviews. Rebecca emphasizes the significance of creating positive learning experiences and a sense of belonging for students. While our perceptions of contribution differ, the team recognizes the value of their

diverse perspectives, using their strengths to engage in the project's rhetoric and contribute to its progress.

2.2 The Intersection of Being Students and Researchers

As we navigate this intersection of academia and research, we reflect on how these roles influence our experiences within the project and beyond. Below we offer insights into our journeys, shedding light on the multifaceted nature of our roles and the impact they have on the project's trajectory.

Deana

"Given that the primary goal of this project revolves around transforming undergraduate education, it's noteworthy that I was an undergraduate student just two years ago. This places me in a unique position to offer insights from the student's perspective while conducting interviews with undergraduate students. I believe collaborating with a graduate student who is further along in their studies can create a more approachable dynamic compared to working with a tenured faculty member. Also, as I am straddling the roles of student and researcher, I am at an intersection that allows me to empathize with students, other stakeholders, and the research team members. I can see and try to understand people's different perspectives on this project. Furthermore, as a current student, I can link theoretical concepts and applications, bridging the gap between some conceptualization strategies and their impact. Additionally, the vantage point of being trained as a teacher and someone who values education has allowed me to witness diverse perspectives on the value students, administrators, advisors, and faculty place on this cross-disciplinary education program."

Rebecca

"As a graduate student researcher, my role was twofold: assisting in managing the overall research implementation and offering my insights to the project team. My responsibilities included data collection and organization, playing a central role in data analysis. During our annual summer retreats, I was instrumental in presenting key findings to the project team, contributing under the guidance of a senior professor of anthropology. I believe my role was pivotal in enriching the project with insights from the data collected. Given the iterative nature of this design project, we had various touchpoints for data sharing, including summer retreats and weekly team meetings. In these meetings, I regularly shared emerging insights from the data. The tangible results of this were evident. For instance, in presenting our research findings, which focused on community development, we successfully initiated a student ambassador program. Overall, I felt my role was being an equal contributor to the success of the project."

The above passages showcase our roles as student researchers within the project, detailing our unique perspectives and contributions. Deana's recent experience as an undergraduate student offers valuable insights from a student's perspective during interviews, fostering an approachable dynamic. Additionally, as told by various stakeholders, her background as a trained teacher

enhances her curiosity about the meaning of the transdisciplinary education setting. Meanwhile, Rebecca, in her twofold role, manages research implementation and contributes significantly to data collection and analysis. Her pivotal role in presenting key findings during team meetings and summer retreats demonstrates her equal contribution to the project's success. Our shared intersection as student researchers enriches the project with a blend of firsthand student experiences and research insights, fostering an understanding of the transformative goals in undergraduate education.

3. The Research Process

Throughout the project, semi-structured interviews, observations, and document analysis were conducted to gather data. We contributed to various aspects of the research at different stages. Below, we detail our roles in the research process and share insights gained from our participation in the project.

3.1 Unveiling the Mechanics of Collaborative Research in Learning Environments

Our journey as graduate students within a research team were marked by a blend of learning, collaboration, and growth. Our experiences offer an illustration of this dynamic interplay between individual skill development and collaborative research endeavors. We relay insight into the interconnectedness of personal growth and collaborative research endeavors, highlighting the transformative potential inherent in graduate student involvement within research teams, depicted below:

Deana

"I first joined the research team during my first semester of graduate school, where I would partake in meetings with Rebecca and a faculty member from the anthropology department, as well as my mentor from engineering/technology. Rebecca and I started having our own meetings where she would teach me how to use different platforms such as NVivo, Microsoft, and Otter a.i. During the first semester, I was also asked to conduct student interviews. I read over the semi-structured interview script and talked with Rebecca about the script. Then, I conducted interviews with students. I would stick to the questions during my first interviews, although the interviews were semi-structured. However, when I started going through other interviews to clean transcripts, I would read through the transcripts of interviews conducted by Rebecca. Reading those interviews showed me how to become a better interviewer. Reading the transcripts helped me understand how to engage with the participants during semi-structured interviews. Between the meetings and working with data, I learned how to be a better researcher and become aware of the tools to help me with the data process. Additionally, within all this, Rebecca and I started wanting to collaborate on our own, in addition to the work necessary for the bigger project."

Rebecca

"The research process was collaborative, exploratory, and capacity building. While I had experience working on other cross-disciplinary projects, every approach is different. In this project we used NVivo Teams, which allowed for a consistent collaborative coding scheme. Each coder, which was either a graduate student in the Polytechnic, myself, and my advisor, coded a set of interviews, crafted memos based off our research questions and observations in the data. Then, we came together to discuss our findings to present to the rest of the team. In this collaborative environment, I found the freedom to draw my own insights and actively contribute them to the group discussions. This opportunity for personal input and team synthesis was enriching. I felt valued as a team member, and it was gratifying to note that the Principal Investigators (PIs) were genuinely interested in my perspectives on the data. Perhaps most exciting is the tangible impact of our work. The data we gathered and analyzed has been used to enhance curriculum development and program activities. Additionally, this project has allowed me to be involved from the outset in manuscript preparation and conference presentations, significantly enriching my professional academic experience."

Deana's involvement in the research team during her first semester of graduate school was marked by a comprehensive learning experience. She learned through meetings with people involved in the research team. Through individual sessions, Rebecca taught Deana how to use various platforms like NVivo, Microsoft, and Otter. This hands-on teaching extended to conducting student interviews, with Deana initially adhering strictly to the semi-structured interview script. However, by reviewing transcripts of interviews conducted by Rebecca, Deana gained insights on becoming a better interviewer. After reflecting on the collaborative research process, Rebecca highlighted its exploratory and capacity-building nature. The project utilized NVivo Teams for consistent, collaborative coding involving graduate students including Rebecca and her advisor. Each coder worked on a set of interviews, contributing to creating memos based on research questions and data observations. The collaborative environment fostered individual insights, with each member actively participating in group discussions. Rebecca emphasized the impact of her work, noting its role in enhancing curriculum development and program activities. Additionally, the project provided opportunities for manuscript preparation and conference presentations, significantly enriching Rebecca's professional academic experience. The synergy between Deana's learning journey and Rebecca's collaborative experience showcases the connection of individual skill development within the broader context of impactful research outcomes.

3.2 Enacting Collaborative Research

Within this context, we share insights into our experiences and contributions to a collaborative research project. We discuss the interaction between individual research pursuits and collaborative project objectives. Our experiences demonstrate the transformative potential of collaborative research endeavors, transdisciplinary exchange, and achieving collective success.

Deana

"Furthermore, my research aligns with this project, and I am conducting a case study on the co-teaching aspect. When I first learned about research, I didn't fully understand what conducting a case study entailed. As time passed, I better understood what components I needed to complete my case study. Clarity was brought through the help of a faculty member from anthropology, Rebecca, and my mentor from engineering/technology two. For my thesis work, I utilized interviews, conducted participant observation, and analyzed some co-teaching documents. Due to the collaborative nature of this team, people bring different perspectives to discussions in big and smaller groups. The team comprises people from liberal arts, business, and engineering technology. All these different minds working together allow innovation to arise. Several research team members have taken on mentoring roles, with four actively collaborating with me on my thesis. As I presented my thesis proposal to the diverse committee, comprised of individuals from the project team, I received feedback from various backgrounds. This dynamic has lent my thesis the ability to embody the collective spirit of the research team and my role within it."

Rebecca

"I also saw how when people bring their own perspective to a research design and implementation it is supportive of the research objectives and in fact enhances the research. As a graduate student interested in working on collaborative projects it was valuable to see how my advisor and fellow anthropologist worked with other disciplines. Overall, I thought there was a strength in us working together. I did understand the tensions of having different ways of approaching the project but thought the fact that everyone liked working together and were invested in the mission of the project made it all possible. In my opinion, this is what made it successful."

Deana provides insight into her research alignment with the collaborative project, emphasizing her case study on co-teaching. With guidance from colleagues on the research team, she navigated conducting interviews, participant observation, and document analysis for her thesis. The diverse team, spanning liberal arts, business, and engineering technology, fosters innovation through varied perspectives. Several research team members are actively mentoring and collaborating on Deana's thesis. The dynamic interactions within the research committee, representing different backgrounds, enrich the spirit of the team and define graduate student one's role within it. Rebecca shared her perspective on collaborative research, highlighting the experience of witnessing multiple perspectives in research design and implementation. As a graduate student keen on collaborative projects, she appreciates the strength derived from cross-disciplinary collaboration. Despite ideas of varied approaches, the shared commitment to the project's mission and the enjoyment of working collaboratively contribute to its success from the perspective of Rebecca.

4. Reflections

While engaged in the same project, we provide distinct accounts of our experiences. This concluding section provides our final reflections on their participation in this cross-disciplinary research project aimed at transforming undergraduate education through transdisciplinary initiatives.

4.1 Exploring Novel Approaches in Education and Educational Research

As members of a collaborative research team, we have embarked on a journey of learning and growth, enriching their perspectives on education and research. Our reflections illuminate the profound impact of this experience on their professional development and outlook on higher education. Our experiences serve as a testament to the importance of embracing diverse perspectives and methodologies in fostering innovation and inclusivity within higher education, as seen below:

Deana

"I have learned that even though I am trained in engineering and technology education, I've realized that I can now approach education from diverse perspectives. This cross-disciplinary experience has not only broadened my outlook on integrated education but has also instilled in me new research methods and ideas that may not have emerged otherwise. I think rather than being exposed to only research methods in my field; I was exposed to methods and frameworks used in various disciplinary research work. I have been motivated during this experience to pursue further research. While having a cross-disciplinary team is beneficial for undergraduate student learning and research, it also served as a learning opportunity for me and a motivation."

Rebecca

"My journey as a graduate researcher on this project has been incredibly enriching, offering learning experiences that I deeply value. I have grown more confident in sharing my perspective as an anthropologist within transdisciplinary teams. This growth has been supportive in shaping my professional identity as a collaborator and researcher. Significantly, I have come to understand the immense value of the project in the context of teaching and learning within a predominantly STEM-focused institution. It has become increasingly clear to me that projects like these are essential in higher education. They challenge traditional educational models and advocate for a more holistic approach where disciplines like anthropology are central and equal partners in these pursuits. In my opinion, there is a pressing need for more programs like this that push the boundaries of education."

Our perspectives converge on the impact of our research experience on education. Deana, with a background in engineering and technology education, expresses how her cross-disciplinary exposure broadened her approach to education. Learning diverse perspectives and research methods beyond her field has motivated her to pursue further research. Similarly, an anthropologist, Rebecca shares her enriching journey within a transdisciplinary team, emphasizing the value of projects that challenge traditional educational models. Both narratives

highlight the importance of cross-disciplinary collaboration in shaping innovative educational approaches and advocating for a more holistic, inclusive framework in higher education.

4.2 Passion for Collaboration and Transdisciplinarity

In higher education, the pursuit of innovation and student success can hinge on the collaborative efforts of individuals from diverse academic backgrounds. As evidenced by our reflections, the value of transdisciplinary collaboration in advancing teaching and learning is undeniable, as evidenced below:

Deana

"During this project, I have learned the value of having people from different academic backgrounds engage in conversation for innovation and student learning. When students are bridging their academic backgrounds to create an innovation or help solve a problem, the purpose of the bigger project is achieved at some capacity, which is nice to see. Furthermore, I realized that the people working on this research team are special as they deeply care about student learning and success, which is evident through the way they teach their classes, the way they engage with each other, and the way they aid in our successes. The research team collaborates to create transdisciplinary learning experiences for students in higher education. One thing that I think all the research team members have in common is the pursuit of their passion, which has led them to a place of meaningful work, me included."

Rebecca

"Working cross-disciplinary in higher education is certainly not a fast-track approach, often hindered by incentives amidst the internal and external pressures typical of research institutions. However, I firmly believe that this interdisciplinary collaboration is a crucial next step for the advancement of teaching and learning across all disciplines. While such endeavors have been successful in some places, the challenges become more noticeable in larger institutions, for me, that's more of a reason to do it! I think about my experience as an undergraduate at another large research university. I would have loved an opportunity like the project. Now, returning to graduate school after gaining early career experience, I see more clearly the immense benefits such projects offer. They are essential for equipping students to tackle the significant challenges that we collectively face in today's world."

We share a common theme in our excerpts about the passion for collaboration and cross-disciplinary education. Deana emphasizes the value of having individuals from diverse academic backgrounds who deeply care about student learning. She recognizes the unique qualities of the research team members and acknowledges that their shared passion has led them to meaningful work. On the other hand, Rebecca acknowledges the challenges of cross-disciplinary collaboration in higher education but firmly believes it is a crucial next step for advancing teaching and learning across all disciplines. We depict the significance of pursuing passion for collaboration, believing it is essential for enhancing the quality of higher education and

equipping students to face challenges in the modern world. Our perspectives align in highlighting the transformation passion can foster for collaboration and transdisciplinary approaches to education.

4.3 Aspirations and Inspirations

The ethos of collaboration and continuous learning emerges as a guiding principle for us. Our reflections offer insights into our aspirations and inspirations for future endeavors, underscoring the transformative potential of cross-disciplinary engagement.

Deana

"I aspire to carry with me the concept of collaborative efforts across disciplines and to be dedicated to learning in every aspect of my future. I intend to learn from peers, mentors, students, and anyone with something to teach. This experience allowed me to observe professionals willing to be collaborative and open to new ideas from professionals spanning disciplinary backgrounds. Being involved with a group like the M3 research team provides an environment where I feel welcomed and confident to share my thoughts, and receive feedback from many different viewpoints, allowing for generative conversations. Furthermore, the quality of undergraduate education is at the forefront of this research, and it is inspiring as a novice researcher and a trained teacher to see people from many backgrounds care about student learning and see the positive impact the faculty are making. Whether applied in my future classroom or research, I am eager to incorporate cross-disciplinary work into all facets of my journey and to continue learning."

Rebecca

"I strongly believe the future of innovation in higher education hinges on partnerships, particularly between the social sciences like anthropology and other disciplines. The effectiveness of technology and innovation is intrinsically linked to the understanding of the people they are designed for, and equally, by the diverse perspectives of those working on these projects. Collaboration is not just a professional interest, but a core personal value of mine, vividly highlighted in initiatives like the project. Through such collaborations, we can do exciting and novel things. I am eager to keep on this journey as I carry out my PhD project that is further looking at collaborative learning spaces on campus. I am particularly interested in exploring who these spaces attract and the innovative approaches they support in educational settings. This research is more than an academic pursuit; it's a quest to understand how we can foster environments that truly enhance innovation in education."

Our reflections on inspiration for future work reveal a shared commitment to collaborative efforts and a dedication to continuous learning in both research and education. Deana expresses her aspiration to embrace collaborative learning across disciplines, drawing inspiration from the professionals she observed during the project. She is eager to incorporate cross-disciplinary work into her future classroom and research endeavors, emphasizing the importance of learning from

peers, mentors, and students. Similarly, Rebecca sees the future of innovation in higher education as reliant on partnerships, particularly between social sciences and other disciplines. Her interest in collaborative learning spaces aligns with a quest to foster environments that truly enhance innovation in education. Both of us convey a shared enthusiasm for collaborative approaches, emphasizing the transformative potential of cross-disciplinary engagement in shaping the future of education and research.

Overall, despite our different disciplinary backgrounds and life experiences, we converged on a shared commitment to fostering transdisciplinary learning experiences and contributing to collaborative endeavors that transcend disciplinary boundaries. Our motivations were rooted in a desire to advance transdisciplinary experiences for students and to learn from diverse perspectives, demonstrating the transformative power of collaborative research projects. Moreover, our personal connections to the project were deeply intertwined with our past experiences and aspirations, highlighting the significance of aligning our passions with our professional pursuits. As graduate students, our roles within the research team allowed us to leverage our strengths and perspectives, contributing to the project's success while also enriching our own academic and personal development. Throughout the research process, we revealed the mechanics of collaborative research in learning environments, shedding light on the dynamics between individual skill development and collaborative research endeavors. Our reflections on our roles within the project highlighted collaboration in driving forward academic inquiry and innovation. Additionally, in exploring novel approaches in education and educational research, we uncovered the impact of our research experience on our professional development and outlook on higher education. Our reflections illuminated the importance of embracing diverse perspectives and methodologies in fostering innovation and inclusivity within higher education. Ultimately, our aspirations and inspirations for future endeavors are guided by collaboration and lifelong learning. We remain committed to embracing transdisciplinary engagement and leveraging our strengths to shape the future of education and research. As we embark on the next phase of our academic and professional journeys, we carry with us the lessons learned and the transformative experiences gained from our participation in this transdisciplinary research project.

Discussion

This CAE adds to the existing literature on graduate student researchers participating in transdisciplinary research projects and teams. By bringing together graduate students from various disciplinary backgrounds, our collaboration enabled us to forge connections beyond our academic silos, thereby expanding our networks. In doing so, it transcended the initial transformative goals of the research endeavor. The findings illustrate how we underwent profound learning, transformation, and inspiration that transcended the boundaries of our disciplinary backgrounds. We discovered innovative approaches to our work and continued to support each other in academic and personal pursuits, often convening regularly. Although we

come from different backgrounds, both personal and academic, we found ourselves collaborating with the mutual goal of enhancing education.

Utilizing the CAE methodology provided us with a platform to delve into introspection, exploring the depths of our individual journeys and uncovering the significance of our collective efforts. Embracing a collaborative approach to the research process, akin to our research, felt like a natural evolution, bringing a sense of fulfillment and cohesion to our work. Moreover, delving into the connections between our research and personal growth was a great experience. It allowed us to recognize the mutual influence we have on each other and the impact of those around us. Moving forward, these insights serve as guiding principles, informing our future endeavors, and shaping our approach to research and collaboration.

We found ourselves operating within a mode heavily influenced by our ongoing research endeavors, particularly as we were concurrently engaged in crafting a paper on this very mode of operation using the CAE methodology. Our aim was to document and reflect on the experiences and transformations encountered while working within this collaborative and transdisciplinary framework. By employing the CAE approach, we were able to delve into the nuances of our collaborative efforts and personal experiences, shedding light on the intricacies of working across disciplinary boundaries. The importance of our work lies in its potential to inform future research teams, especially those comprised of graduate student researchers with diverse disciplinary backgrounds. We believe that sharing our insights and reflections on the transformations that can occur outside the intended scope of a research project is essential for fostering a deeper understanding of collaborative research practices. By documenting our journey and the unexpected outcomes that emerged from our collaborative efforts, we provide insights into the complexities of transdisciplinary teamwork and the potential for personal and professional growth that it offers. Our hope is that by sharing our experiences, future research teams will be better equipped to navigate the challenges and capitalize on the opportunities presented by collaborative research endeavors. By highlighting the transformative power of transdisciplinary collaboration, we aim to inspire and empower graduate student researchers to embrace the rich diversity of perspectives and approaches that can contribute to meaningful research outcomes. Ultimately, we believe that our work contributes to the broader conversation on collaborative research methodologies and the importance of fostering transdisciplinary dialogue and collaboration in academic settings.

Limitations

While our study is limited by its small sample size, comprising only two graduate researchers engaged in a single transdisciplinary research team, this setup aligns well with the principles of the CAE methodology. It allows us to immerse ourselves deeply in the research process, blending our insights and conclusions [16]. However, it's important to acknowledge that the insights drawn from our study may not be fully representative of broader populations [16]. Our reliance on self-reported data is another limitation because data can be influenced by our

personal experiences and biases. Interpreting our findings within the framework of CAE is crucial, even though it means forgoing additional layers of critical examination, without these checks, our study risks perpetuating our individual and collective insider perspectives [16]. As researcher-participants, we lacked mechanisms to subject our data analysis to external scrutiny, potentially limiting the depth and breadth of our insights.

Conclusion and Recommendations

In pursuing transdisciplinary learning, our experiences as graduate student researchers in engineering technology and anthropology on an NSF Improving Undergraduate STEM Education research project have provided insights into the transformative potential of cross-disciplinary collaboration, especially for graduate students. Our diverse disciplinary backgrounds and lived experiences have uniquely positioned us to contribute meaningfully to a project that spans engineering technology, anthropology, and business academic disciplines. Through collaborative efforts, we have delved into the nuts and bolts of learning, enacting collaborative research practices, and reflecting on our roles and motivations. The significance of transdisciplinary collaboration in higher education cannot be overstated, as it challenges traditional educational models and advocates for a holistic transdisciplinary approach. Our project exemplifies the dynamic nature of cross-disciplinary research, as seen through how we are both attached to the work in new and vital ways. Furthermore, the active participation of graduate students in this endeavor has been recognized as a crucial value addition by external reviewers, highlighting the potential impact of transdisciplinary ventures on transforming higher education.

As we reflect on our motivations, strengths, and roles, it becomes evident that our passion for collaboration and transdisciplinary education has been strengthened. The inspiration for future work resonates in our commitment to continue learning, incorporating transdisciplinary approaches in education and transdisciplinary collaborations in research. Our journeys have enriched our individual academic experiences and set us on the path to becoming transdisciplinary scholars. Collaboration is at the heart of transdisciplinary education, and our project is a testament to the transformative power of bringing diverse perspectives together. The project's focus on delivering transdisciplinary experiences for students has driven our motivation, emphasizing the centrality of learning in the research endeavor. Collaboration between disciplines has paved the way for innovative approaches to teaching and learning.

As for our positionality in the greater scheme of the work, being at the intersection of students and researchers has enriched the project with firsthand experiences and insights, fostering a deeper understanding of the goals of undergraduate education. The research process has been a dynamic and shared journey involving collaborative coding, analysis, and data presentations. Utilizing tools such as NVivo Teams and Microsoft Teams has contributed to the iterative research design, enhancing the project's outputs. Our participation in project meetings, community events, and data review sessions has strengthened the collaborative process and

ensured consensus building. It provided meaningful insights into the research, emphasizing the need to pull out the things not always covered or highlighted in educational research. Overall, our experiences as graduate student researchers in this transdisciplinary research project have deepened our understanding of collaborative research and inspired us for future work. The passion for collaboration and cross-disciplinary education has been a driving force, and we are eager to continue contributing to the transformation of higher education through innovative and inclusive approaches.

Based on our experiences as graduate student researchers engaged in a transdisciplinary NSF Improving Undergraduate STEM Education project, we offer the following recommendations for future practice and research:

1. Embrace Transdisciplinary Collaboration Among Graduate Students: Future research endeavors in higher education should prioritize and embrace transdisciplinary collaboration through cross-college collaborations of not only faculty members, but the graduate students as well. Our project highlighted the transformative potential of cross-disciplinary collaboration, especially for graduate students through having team meetings, and informal mentorship of a graduate student who has been on the project longer. By bringing together individuals from diverse disciplinary backgrounds, projects can leverage unique perspectives and frameworks to address calls for transformation in undergraduate education and develop graduate student identity as transdisciplinary researchers. Our active participation as graduate students in the project was recognized as added value by an external reviewer. Future research initiatives should acknowledge and leverage the contributions of graduate students, recognizing their potential to enrich projects with firsthand experiences, insights, and innovative ideas. Graduate students aid in analyzing the data, and thus can bring meaning to the research, therefore collaboration among graduate students and faculty can promote relationships that foster further collaborative efforts and work. Furthermore, leveraging collaborative research tools such as NVivo Teams and Microsoft Teams can enhance the research process by facilitating communication, data sharing, and collaborative analysis. Lastly, encourage reflective practices among graduate student researchers to deepen their understanding of their motivations, strengths, and roles within research projects. Reflective practices can help graduate students articulate their contributions, identify areas for growth, and align their aspirations with the goals of the research project.
2. Personality Study: Evaluate the characteristics and traits of individuals that contribute to successful collaboration in team environments. Collaborative work has become increasingly prevalent. Explore how personality traits impact the ability to work collaboratively. Personality traits such as openness, agreeableness, conscientiousness, extraversion, and emotional stability may play significant roles in determining an individual's collaborative capacity. By examining these traits and their interactions, the research aims to identify key predictors of successful collaboration. By identifying the personality traits associated with successful collaboration, educators and trainers can design interventions to cultivate these traits and promote effective teamwork.

In conclusion, our experiences as graduate student researchers have provided valuable insights into the potential of transdisciplinary collaboration in higher education research. By embracing transdisciplinary approaches, recognizing the value of graduate student involvement, promoting reflective practices, utilizing collaborative research tools, focusing on delivering transdisciplinary experiences, and encouraging passion for collaboration, future research endeavors can contribute to the advancement of innovative and inclusive approaches in higher education.

The research reported in this paper was supported in part by the U.S. National Science Foundation (NSF) under the award DUE #2044288. This content is solely the responsibility of the authors and does not necessarily represent the official views of the NSF.

References

- [1] Brodin, E. M., & Avery, H. (2020). Cross-Disciplinary Collaboration and Scholarly Independence in Multidisciplinary Learning Environments at Doctoral Level and Beyond. *Minerva* (London), 58(3), 409–433. <https://doi.org/10.1007/s11024-020-09397-3>
- [2] A. Horn, A. Scheffelaar, E. Urias, and M. B. Zweekhorst, "Training students for complex sustainability issues: A literature review on the design of inter- and transdisciplinary higher education," *International Journal of Sustainability in Higher Education*, vol. 24, no. 1, pp. 1–27, 2023. [Online]. Available: <https://doi.org/10.1108/IJSHE-03-2021-0111>
- [3] J. Piaget, "Cognitive development in children: Development and learning," *Journal of Research in Science Teaching*, vol. 2, pp. 176-186, 1964. [Online]. Available: <http://dx.doi.org/10.1002/tea.3660020306>
- [4] E. Jantsch, "Inter- and transdisciplinary university: A systems approach to education and innovation," *Policy Sci*, vol. 1, pp. 403-428, 1970. [Online]. Available: <https://doi.org/10.1007/BF00145222>
- [5] G. Strimel et al., "Understanding the values of, and institutional barriers toward, transforming undergraduate learning in the pursuit of innovation," presented at the 2022 ASEE Annual Conference & Exposition, August 23, 2022. [Online]. Available: <https://peer.asee.org/understanding-the-values-of-and-institutional-barriers-toward-transforming-undergraduate-learning-in-the-pursuit-of-innovation>
- [6] J. Thompson Klein, "Learning in transdisciplinary collaborations: A conceptual vocabulary," in D. Fam, L. Neuhauser, and P. Gibbs, Eds., *Transdisciplinary Theory, Practice and Education: The Art of Collaborative Research and Collective Learning*, 1st ed. Springer International Publishing, 2018, pp. 1–13. [Online]. Available: <https://doi.org/10.1007/978-3-319-93743-4>
- [7] P. Leavy, *Essentials of Transdisciplinary Research*. New York, NY: Routledge, 2016.
- [8] C. Klein, "Negotiating Cultural Boundaries Through Collaboration: The Roles of Motivation, Advocacy and Process," *Innovative Higher Education*, vol. 42, no. 3, pp. 253–267, 2017. [Online]. Available: <https://doi.org/10.1007/s10755-016-9382-7>

[9] T. Augsburg, "Becoming Transdisciplinary: The Emergence of the Transdisciplinary Individual," **World Futures: The Journal of New Paradigm Research*, vol. 70, no. 3–4, pp. 233–247, 2014.

[10] A. Bruce, C. Lyall, J. Tait, and R. Williams, "Interdisciplinary Integration in Europe: The Case of the Fifth Framework Programme," *Futures*, vol. 36, no. 4, pp. 457–470, 2004.

[11] U. Felt, J. Igelsböck, A. Schikowitz, and T. Völker, "Growing into What? The (Un-)Disciplined Socialization of Early Stage Researchers in Transdisciplinary Research," *Higher Education*, vol. 65, no. 4, pp. 511–524, 2013. [Online]. Available: <https://doi.org/10.1007/s10734-012-9560-1>

[12] P. McIlveen, "Autoethnography as a method for reflexive research and practice in vocational psychology," *Australian Journal of Career Development*, vol. 17, no. 2, pp. 13–20, 2008. [Online]. Available: <https://doi.org/10.1177/103841620801700204>

[13] C. Ellis, T. E. Adams, and A. P. Bochner, "Autoethnography: An Overview," *Historical Social Research / Historische Sozialforschung*, vol. 36, no. 4 (138), pp. 273–290, 2011.

[14] R. Sawyer and J. Norris, "Duoethnography: A Retrospective 10 Years After," *International Review of Qualitative Research*, vol. 8, no. 1, pp. 1–4, 2015. [Online]. Available: <https://doi.org/10.1525/irqr.2015.8.1.1>

[15] H. Chang, F. Ngunjiri, and K. A. C. Hernandez, *Collaborative Autoethnography*. Routledge, 2013. [Online]. Available: <https://doi.org/10.4324/9781315432137>

[16] R. Logue-Conroy et al, "Doctoral Students' Academic and Professional Network Development: A Collaborative Autoethnography of Students Engaged in Fatherhood Research," *International Journal of Doctoral Studies*, vol. 16, pp. 611-631, 2021. Available: <https://www.proquest.com/scholarly-journals/doctoral-students-academic-professional-network/docview/2610394057/se-2>. DOI: <https://doi.org/10.28945/4869>.