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SOUTHEASTERN STEM EDUCATION RESEARCH CONFERENCE

Celebrating 20 years of STEM Education Research

BIRMINGHAM, ALABAMA
JANUARY 9–10

2026

20th Annual Southeastern STEM Education Research Conference
January 9-10, 2026

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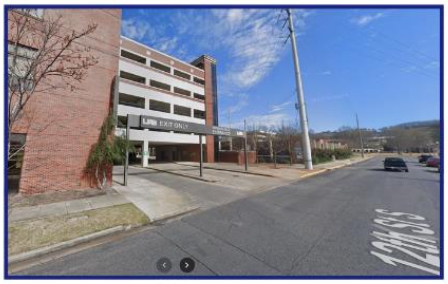
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UAB PARKING MAP



1 12th Street Parking (Deck 2 or above)



2 Heritage Hall



Street parking also available (free after 5pm)

3 Chemistry Building



4 UAB Alumni House



Limited parking spaces available at Alumni House

SCHEDULE

FRIDAY, JANUARY 09

12:00 PM	Registration Opens - Heritage Hall Lobby
1:30 - 3:00 PM	Early Career Panel Heritage Hall, Room 102
2:45 - 3:30 PM	Refreshments, Heritage Hall Lobby
3:15 - 4:45 PM	Project Management Workshop Chemistry, Room 101
3:15 - 4:35 PM	Oral Sessions: Math Education & STEM Education
4:30 - 5:00 PM	Poster Session Setup
5:00 - 6:00 PM	Poster Session, Heritage Hall Lobby
6:00 - 8:00 PM	Dinner & Keynote Presentation, Alumni House Ballroom

SCHEDULE

SATURDAY, JANUARY 10

7:30 - 9:00 AM	Registration - Heritage Hall Lobby
8:00 - 9:00 AM	Breakfast - Heritage Hall Lobby
9:00 - 10:25 AM	Oral Sessions: Biology Education Math Education STEM Education
10:45 - 11:45 AM	Oral Sessions: Chemistry Education STEM Education
12:00 - 1:00 PM	Lunch - Heritage Hall Lobby
1:10 - 2:30 PM	Oral Sessions: Biology Education STEM Education Chemistry Education

EARLY CAREER PANEL

JANUARY 9, 2026
1:30 - 3:00 PM

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HERITAGE HALL, ROOM 102

As we celebrate the 20th anniversary of SSERC in 2026, we are honored to open the conference with the Early Career Panel, generously sponsored by the Center of Excellence in STEM Education and the Clemmer College of Education and Human Development at East Tennessee State University. Over the past two decades, SSERC has remained committed to fostering an inclusive and supportive environment for graduate students and early-career professionals, and this tradition continues as a hallmark of our program.

We warmly invite participants at every career stage to join this event—both to encourage and support the next generation of researchers, and to enrich their own conference experience. As we reflect on twenty years of progress and look ahead to the future, we are delighted to continue building connections that strengthen our field and community.

PANEL MODERATOR



Sarah K. Bleiler-Baxter, Ph.D.
Professor, Department of Mathematical Sciences
Associate Dean for Faculty Affairs,
College of Basic and Applied Sciences
Middle Tennessee State University

Dr. Sarah K. Bleiler-Baxter is a Professor of Mathematical Sciences at Middle Tennessee State University whose research explores how students and faculty learn, teach, and reason in undergraduate STEM environments. Her scholarship includes extensive contributions to understanding how undergraduates learn mathematical proof in collaborative classroom settings, as well as research on STEM faculty peer observation and departmental culture. She currently serves as PI or co-PI on multiple NSF-funded projects, including the Advancing the Culture of Teaching in STEM (ACT-STEM) initiative, which investigates how strength-based reflection can support meaningful instructional and organizational change. Dr. Bleiler-Baxter has also collaborated across disciplines to study why students persist in or leave STEM majors, seeking to illuminate the structures and experiences that shape student motivation. A committed mentor and community builder, she works closely with doctoral students, postdoctoral scholars, and early career faculty to support their development as researchers and educators. She is currently serving as Associate Dean for Faculty Affairs where she aims to support early career faculty, and she is honored to facilitate this year's Early Career Panel at SSERC.

EARLY CAREER PANELISTS



Ashley S. McGuire, M.L.I.S., Ph.D.
Assistant Professor
STEM Librarian for Engineering & Chemistry
The University of Alabama at Birmingham



Alyssa Freeman, Ph.D.
Postdoctoral Research Associate
Middle Tennessee State University



Michelle Wooten, Ph.D.
Assistant Professor of Astronomy Education
University of Alabama at Birmingham



Kingsley Y. Adamoah, Ph.D.
Postdoctoral Research Associate
Department of Mathematics and Statistics
Arkansas State University-Jonesboro

Ashley S. McGuire, M.L.I.S., Ph.D.

Dr. McGuire is an Assistant Professor and the STEM Librarian for Engineering & Chemistry at the University of Alabama at Birmingham. Much of her academic and scholarly background is in physical chemistry – her doctoral research was in computational chemistry, which allowed her to communicate and collaborate with other chemists and physical scientists in a wide variety of chemical subfields. She is deeply invested in the scholarship of teaching and learning, particularly when it comes to innovations in the STEM classroom, as this is an aspect of academic careers that is largely neglected in many doctoral programs in STEM. She is also deeply passionate about facilitating equitable access to resources and unwavering support for students, staff, and faculty alike regardless of background or identity.

Alyssa Freeman, Ph.D.

Dr. Freeman received her bachelor's degree in microbiology and master's degree in biology from Idaho State University in Pocatello, Idaho. She then moved to Murfreesboro, Tennessee and received her Ph.D. in Biology Education at Middle Tennessee State University (MTSU), where she studied professional development of graduate teaching assistants and departmental teaching culture. Dr. Freeman is currently a postdoctoral researcher at MTSU where she is working on three NSF-funded grants related to STEM education. In her free time, Alyssa loves hiking and being outside, watching reality tv, and making bread with her sourdough starter named Doughlene.

Michelle Wooten, Ph.D.

Michelle Wooten, PhD, is an assistant professor of astronomy education at the University of Alabama at Birmingham, where she welcomes the world of astronomy to hundreds of nonscience majors every semesters. As teaching faculty, Dr. Wooten's scholarship is focused on community education and engagement in protecting the night sky. To this end, she leads the Campus SHINE Lab at UAB, the organization Starry Skies South, and recently wrote and taught a service-learning course on light pollution mitigation at UAB and beyond.

Kingsley Y. Adamoah, Ph.D.

Dr. Kingsley Adamoah is a postdoctoral research associate in the Department of Mathematics and Statistics at Arkansas State University. He is currently researching on designing interventions on implementing effective teaching practices and mentorship for students' success in undergraduate mathematics courses. Dr. Adamoah earned his Ph.D. in Mathematics and Science Education with concentration in Mathematics Education from Middle Tennessee State University, where he researched on calculus students limit conceptions and representational approaches. Dr. Adamoah earned his first master's degree (MS) in Mathematics from Ohio University and second MS in Teaching and Curriculum from Syracuse University. He also has a BS in Mathematics from University of Mines and Technology in Ghana.

PROJECT MANAGEMENT WORKSHOP



Aspen Malone
Project Manager
Tennessee STEM Education Center
Middle Tennessee State University

Aspen Malone is a research project manager at the Tennessee STEM Education Center at Middle Tennessee State University, where she helps lead many initiatives that support STEM education. She earned her B.S. in Biochemistry from Abilene Christian University and is currently pursuing an MBA at MTSU, blending scientific training with organizational leadership and project strategy. Aspen manages multiple large-scale research projects funded by agencies including the National Science Foundation, the U.S. Department of Agriculture, and the Health Resources and Services Administration. Her work focuses on coordinating teams, aligning deliverables, and keeping projects moving smoothly from planning through implementation. She is especially committed to fostering strong collaboration, clear communication, and a positive team culture that supports research excellence. Aspen brings a practical, people-centered approach to project management, helping teams translate ambitious ideas into measurable outcomes.

WORKSHOP TAKEAWAYS

Fostering productivity and strengthening team dynamics are essential for success across university, research, teaching, and administrative contexts. The workshop, “Inside the Work: Building Strong Teams and Smarter Workflows,” will share practical, research-informed strategies for helping teams increase efficiency while cultivating a positive, trusting culture.

Organized around four key sections (Building Trust, Understanding Inclinations, Enhancing Transparency, and Productivity Tools) participants will explore ways to establish trust, leverage diverse working styles, create open communication channels, and use tools that streamline workflows. Interactive demonstrations will introduce approaches such as Brené Brown’s Core Values Exercise and “Paint a Picture” language, the 6 Types of Working Genius framework, Scrum and other agile practices, Gantt charts, and AI-supported productivity tools, alongside opportunities for reflection and discussion.

By the end of the session, attendees will better understand the role of trust and transparency in team effectiveness, recognize and capitalize on different working inclinations, and leave with concrete tools and strategies they can apply immediately. This workshop is especially valuable for those engaged in collaborative environments within a university, drawing on materials successfully implemented across teams at Middle Tennessee State University to build inclusive, accountable, and highly productive team environments.

We are grateful to the College of Basic and Applied Sciences at Middle Tennessee State University for supporting the oral sessions, the Oakley STEM Center at Tennessee Tech University for supporting the poster session, and the MSE program at Middle Tennessee State University for supporting the keynote.

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BANQUET

KEYNOTE SPEAKER

DR. MICHAEL SAAG
THE UNIVERSITY OF ALABAMA AT BIRMINGHAM

FRIDAY JANUARY 9, 2026

AT 6:00-8:00 PM

UAB ALUMNI HOUSE



UAB MEDICINE®

Dr. Saag is Professor of Medicine, Microbiology and Public Health at the University of Alabama at Birmingham. During his fellowship in Infectious Diseases, Dr. Saag conceived the concept of a comprehensive HIV outpatient (1917) clinic dedicated to the provision of comprehensive patient care in conjunction with the conduct of high-quality clinic trials, basic science, and clinical outcomes research.

Over the last 35 years, the clinic has treated more than 13,000 patients and has become recognized as one of the best sites for clinical research and care in the United States. Dr. Saag has published over 650 articles in peer reviewed journals, including the first description of the quasispecies nature of HIV (Nature, 1988), the first use of viral load in clinical practice (Science, 1993), the first description of the rapid dynamics of viral replication (Nature, 1995), the first guidelines for use of viral load in practice (Nature Medicine, 1996), the first proof of concept of fusion inhibition as a therapeutic option (Nature Medicine, 1998), and directed the 'first-in- patient' studies of 7 of the 30 antiretroviral drugs currently on the market.

Dr. Saag has received the Myrtle Wreath Award from Hadassah, was listed as one of the top ten cited HIV researchers by Science (1996), and received multiple Argus Awards for Best Lectures to the 1st year medical students at UAB. In 2014, Dr. Saag was named the Castle-Connolly National Physician of the Year Award for Clinical Excellence and was inducted into the Alabama Healthcare Hall of Fame. He is Co-Editor of the Sanford Guide. During the COVID epidemic, Dr. Saag has appeared frequently on CNN, MSNBC, Yahoo Finance, and the Paul Finebaum Show and has published frequent OpEd features in the Washington Post. Dr. Saag published a memoir entitled, "Positive: One doctor's encounters with death, life, and the US Healthcare System," which is in its third printing.

Friday January 9, 2026

Oral Presentations - Math Education **3:15 PM - 4:35 PM**
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ORAL PRESENTATIONS

AUTHORS AND ABSTRACTS



2026

Research Experiences for Preservice Mathematics Teachers

Sarah Hartman (Middle Tennessee State University)
& Nicholas Fortune (Western Kentucky University)

Engaging in research as an undergraduate student has been shown to have positive impacts on future job-related skills, writing abilities, interpersonal and communication skills (Ishiyama, 2002; Jahan & Aly, 2018), as well as independence, self-confidence, and perseverance (Lopatto, 2010). Further, the notion of research in teacher education is an important building block for data literacy (Mandinach & Gummer, 2016) and pre-service teachers (PSTs) professional development (Kara & Corum, 2022). Though preservice mathematics teachers (PSMTs) can be exposed to research (e.g., through reading research articles in their classes), the act of *designing* and *conducting* research is seldom a component of mathematics preservice teacher education (c.f., DeVore & Munk, 2015). *Designing* and *conducting* research may include, but is not limited to reading research articles, designing a study, collecting data, analyzing data, and disseminating results. In this project, we theorize that the skills and competencies of research mirror the skills and competencies needed for the act of teaching. To explore this, we conducted a study involving six elementary or middle-grades PSMTs who designed, conducted, and disseminated their own research during one year of their teacher preparation programs. Throughout this process, our research team investigated their experiences. We sought to answer the following research questions: *1) How do research experiences support PSMTs understanding of and knowledge related to mathematics education research? 2) How does designing and conducting research support PSMTs skills related to research?* To answer these research questions, we share results from interviews and autoethnographies.

Brief Background Literature

The Association of Mathematics Teacher Educators [AMTE] emphasizes that PSMTs who are well prepared are aware of the processes of research (AMTE, 2017). Most examples of research experiences involve PSMTs reading research (Manak & Young, 2014; van Ingen et al., 2016). Examples of PSTs conducting research cite issues with PST's attitudinal barriers to research (Baker, 2022; Dobozy, 2012), self-efficacy (West & Meier, 2019), relatability to their own teaching practice (Baker, 2022), and time constraints due to coursework (Baker, 2022; Manak & Young, 2014). Each of these examples of interactions with research are thought to contribute to the development of PSTs critical thinking skills (Manak & Young, 2014), a deep understanding of the field of education (Baker, 2022), and the ability to make informed instructional decisions (Groth et al., 2020). We conjecture that *designing* and *conducting* research brings something new to teacher preparation. While the mathematics education community is aware of research-based strategies to properly prepare teachers, we posit that the skill of research has the potential to inform the skill of teaching.

Methods, Data Collection, and Analysis

This study was conducted at a university in the southern United States and followed longitudinal case study methodologies (Yin, 2003). Our study is bounded in time (one full year) and space (our university). Our case is instrumental (Stake, 1995) in that it is not just these six PSMTs that are of interest but rather who they represent as PSMTs learning about and

conducting research in general. PSMTs conducted and presented a study of their choosing over the course of a year while meeting regularly with the author-researcher team. The year was broken into two phases. During the first phase, PSMTs read research and participated in discussions about what it means to do qualitative research, the design and purpose of semi structured interviews, and appropriate analysis techniques for working with qualitative data. Following each meeting in Phase 1, the PSMTs had specific prompts to refer back to in 'living journals', or autoethnographies (Ellis et al., 2011). Autoethnography incorporates personal narrative and external sources (e.g., scholarly articles, interviews, field notes, etc.) to present and examine personal experiences and the effects of membership in social groups on one's sense of self (Ellis et al., 2011). Throughout this process, PSMTs generated ideas of topics they may want to pursue. After selecting a topic, PSMTs read relevant literature on their topic to aid in preparation of an interview protocol to be used during interviews (i.e., Phase 2). During Phase 2, interviews and analysis of PSMTs data took place. Once PSMTs began to analyze interview data, the primary focus of the meetings with the author-research team were to serve as a reliability to ensure data analysis was appropriate, discuss evidence from these that support their research questions, and to prepare for conference presentations. We then conducted semi-structured interviews after all PSMTs had presented at the student researcher conference on campus. Interviews occurred on Zoom and were roughly 30 minutes.

All living journals were coded using open thematic analysis (Braun & Clarke, 2006). Each author-researcher coded all of the data individually, then met and developed an agreed upon codebook. Any disagreements were worked out on a case-by-case basis. The interviews followed a similar coding structure, but rather than coding all six interviews individually, we coded only two interviews (individually) to develop a codebook. This initial codebook was collaboratively created, then all interviews were coded again. During this, the codebook was refined, and this iterative process was continued until complete agreement was reached.

Summary of Findings

Part of this study aimed to answer how research experiences for PSMTs support their understanding of and knowledge surrounding mathematics education research (RQ1). Throughout this study, PSMTs often noted a disconnect between research-based teaching strategies that they often learned about in their teacher preparation program and understanding the intricacies of the development of said research-based strategies. Findings indicate despite initially having little to no research experience and expressing surprise at the complexity of the research process, the participants found significant value in engaging with research. Informal reflection and journaling through their living journals proved to be particularly helpful, allowing them to process and internalize their learning. Because the living journals not only prompted participants about their future teaching but also about the content, they were learning during Phase 1, participants were able to further engage with aspects of the research process. The conference experience enhanced their knowledge of the research process as well.

Another portion of this study investigated how these research experiences supported skills related to research (RQ2). Interviews revealed that participants frequently referenced a perceived gap in their research proficiency, highlighting its impact on their ability to independently implement or comprehend research findings. Discussions around using research as a tool extended to being able to collaborate with other teachers about what practices in a classroom would work for them, as well as being able to use research to plan lessons. Reflecting on their specific research projects prompted participants to envision their future roles as educators, particularly in fostering impactful teacher-student relationships and advocating for educational

efficacy. Based on these findings, there is an opportunity to infuse more research experiences into mathematics teacher education. This includes opportunities for PSMTs to design, conduct, and disseminate research. In future research, we aim to implement this research experience more directly into the coursework of our programs. We also aim to include a wider sample, including future high school mathematics teachers.

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Enhancing Student Engagement and Teacher Perceptions with Desmos Classroom Activities in High School Mathematics

Emily McDonald
(Hamilton County Schools)

Introduction:

The use of educational technology, such as Desmos Classroom Activities, has transformed the way students interact with mathematical content. Desmos Activities can provide dynamic, interactive visualizations that encourage student engagement and facilitate a deeper understanding of mathematical concepts. Research suggests that technology integration in classrooms can enhance student engagement by making learning more interactive and accessible, which, in tum, promotes higher levels of motivation and participation (Clark-Wilson & Noss, 2015). Additionally, digital tools like Desmos provide opportunities for personalized learning, instant feedback, and collaboration, which are crucial for maintaining student interest in challenging subjects such as mathematics (Pierce, Stacey, & Barkatsas, 2007). In Algebra 2 and Pre-Calculus courses, where students often struggle with topics such as functions, transformations, and conic sections, Desmos presents an opportunity to improve student motivation and engagement. This study investigates the impact of Desmos Classroom Activities on student engagement and motivation. Also, this study explores teachers' perceptions of utilizing educational technology, such as Desmos, effectively and the challenges teachers face when integrating technology.

The study builds on the work of Pierce, Stacey, and Barkatsas (2007), as well as more recent literature on the intersection of technology and student motivation (Clark-Wilson & Noss, 2015). By focusing specifically on Desmos Classroom Activities, this research adds to the growing evidence that digital tools can not only enhance engagement but also provide opportunities for deeper conceptual understanding. Additionally, this study contributes to the discussion on how technology can be leveraged to promote equity in mathematics classrooms, particularly for students who struggle with traditional instructional methods.

Research Questions:

This study addresses two key research questions:

• How do Desmos Classroom Activities impact student engagement and motivation in Algebra 2 and Pre-Calculus courses?

• What are teachers' perceptions, successes, and struggles with using educational technology tools, such as Desmos Classroom Activities, in their classrooms?

Methodology and Timeline:
The study was conducted over a semester in a high school setting involving two Algebra 2 classes and one Pre-Calculus class at the author's school. Desmos Classroom Activities were integrated into lessons focused on functions, transformations, and conic sections. Also, teachers were administered surveys about their perceptions of technology integration, specifically utilizing the free Desmos Classroom Activities website.

Data Collection:
- *Surveys:* Pre- and post-surveys were administered to students to measure changes in engagement and motivation. Surveys also collected data from teachers regarding their experiences with Desmos, including perceived benefits and challenges.
- *Classroom Observations:* Observations were conducted during Desmos-based lessons to capture student participation and interaction with the platform.
- *Interviews:* A subset of students and teachers participated in semi-structured interviews to provide deeper insights into their experiences and perceptions of Desmos.

Timeline:
- Weeks 1-2: Baseline data collection through student pre-surveys and teacher surveys.
- Weeks 3-9: Desmos Classroom Activities were integrated into key lessons in Algebra 2 and Pre-Calculus.
- Weeks 10-11: Post-surveys and interviews were conducted to evaluate changes in the engagement and motivation of students.

This research is particularly timely given the ongoing efforts to ensure equitable access to quality mathematics education. Desmos Classroom Activities allow for differentiated instruction that can reach diverse learners, thus supporting NCTM's broader mission of advancing equity in mathematics education. This study also contributes to the broader STEM education agenda by fostering computational thinking and engaging students in problem-solving in dynamic ways.

This study provides important insights into the role of educational technology in reshaping how mathematics is taught. By offering real-time feedback, interactive visualizations, and collaborative opportunities, Desmos Activities challenges traditional teaching methods and supports a more student-centered approach. The results of this study contribute to the growing body of research advocating for the integration of digital tools as a means of enhancing student engagement and learning outcomes.

Data Analysis & Results:

Quantitative data from the student pre- and post-surveys were analyzed using paired t-tests to determine significant changes in motivation and engagement.

Observational data were coded for participation levels, and qualitative data from interviews were thematically analyzed to uncover trends in student and teacher experiences with Desmos.

The preliminary results indicate an increase in student engagement and motivation, with students reporting greater enjoyment and confidence in learning math concepts using Desmos.

The platform's interactive visualizations allowed students to explore functions and transformations in ways that enhanced their conceptual understanding. Classroom observations/recordings support these findings, with more students actively participating and collaborating with peers during Desmos-based activities.

In terms of teacher perceptions, educators noted that Desmos provided valuable tools for real-time formative assessment, enabling them to gauge student understanding and offer immediate feedback. However, challenges included the initial learning curve in mastering the platform's features and the time required for lesson preparation. Teachers appreciated Desmos' potential for differentiation but indicated a need for professional development to maximize its effectiveness.

Linking Research and Practice:

Through this research, the aim is to bridge the gap between theoretical frameworks and practical applications in the classroom. The findings from this study could offer concrete strategies that can be implemented by K-12 teachers to enhance engagement and motivation using free, online Desmos Activities. Furthermore, district leaders and coaches could provide professional development opportunities for teachers focused on maximizing technology use in mathematics education to overcome integration challenges.

Conclusion:

Desmos Classroom Activities enhanced student engagement and motivation in Algebra 2 and Pre-Calculus courses, offering an interactive platform for exploring complex mathematical concepts. The study also highlights teachers' overall positive perceptions of Desmos, though they face challenges in integrating technology due to time constraints and a lack of comprehensive training. These findings suggest that Desmos can be a powerful tool for enhancing both teaching and learning in mathematics when accompanied by adequate teacher support. Future research could focus on long-term impacts on student achievement and explore ways to streamline the integration of Desmos and similar technologies into daily classroom practices.

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Effective Teaching Practices: Faculty Reflective Expectations and Lived Experiences in Undergraduate Mathematics Instruction

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Introduction and Literature Review

Identification and implementation of effective teaching practices play a critical role in promoting students' positive learning experiences and success. A body of research highlights that teaching practices such as active learning (e.g., Freeman et al., 2014; Litster et al., 2020; Theobald et al., 2020), culturally responsive instruction (Bonner & Adams, 2012; Leonard, 2018), application of pedagogical knowledge innovations (Boaler, 2022; Maass et al., 2019), and productive teaching-related faculty feedback (Bleiler-Baxter et al., 2021; Lane et al., 2022; Yang & Carless, 2013)—can make significant difference in reducing students' learning barriers, fostering motivation and confidence, and promoting students' positive learning experiences in mathematics. One common mechanism that has been widely used is traditional professional development workshops as part of interventions to promote best practices in teaching mathematics (Borko et al., 2015; Loucks-Horsley et al., 2009; Vescio et al., 2008). However, over the years, such professional developments have been regarded as one-time, one-way structure, which limits sustainability and department-wide implementation. Thus, there remains a gap in understanding how professional development initiatives can be restructured to foster long-term, department-wide culture of pedagogical intervention, and implementation; especially within teaching-focused mathematics departments.

Therefore, we argue that to build reform initiatives for effective teaching and learning, it requires an initial step of identifying and utilizing key components of *faculty reflective expectations* and *professional lived experiences* on teaching and learning. Hence, one of the goals of this study is to identify effective teaching practices by unpacking the key components of faculty expectations and lived experiences about the work of teaching.

Significance of Study and Research Question

This study focuses on supporting students to build their learning experiences in mathematics, especially in general education mathematics courses. The guiding research question is *How can faculty reflective expectations and lived experiences be structured and utilized as assets to inform and reform teaching and learning in undergraduate mathematics?*

Theoretical Framework

This study was framed using the constructs of feedback triangle (Yang & Carless, 2013) and Time-sensitive, Reciprocal, Inclusive, and Operative (TRIO) process of peer observation (Bleiler-Baxter et al., 2021). Yang and Carless named three dimensions of effective feedback: cognitive, social-affective, and structural dimension. The author's descriptions of these three dimensions focused on instructor-student levels of teaching and learning. For our study, we only focused on instructor-instructor feedback as a step to implementing and improving effective teaching practices in undergraduate general education mathematics courses. Thus, we wish to use this intervention to identify and organize other dimensions of feedback for effective instruction because Yang and Carless acknowledged that "there are obviously alternative ways of naming and organizing dimensions of the feedback process." (p. 287). Ultimately, instructors' reflective expectations and lived experiences can be used to establish and strengthen key teaching practices

in mathematics departments with the goal of advancing students productive learning experiences in mathematics. Therefore, the goal for this study's framing is to establish instructional intervention that uses faculty expectations and experiences as assets for reforming teaching practices that enforce identifying and utilizing students (1) different learning experiences, (2) learning challenges, and (3) diverse backgrounds.

Methodology

Study Context, Data Sources, and Data Analysis

In the initial stage, we began this intervention in Fall 2025 at a large public university in the southeastern United States with three integrated components of data sources: (1) team-lead instructor observation (contextual inquiry)—to build instructor rapport and lay out intentions, (2) instructors sharing expectations for students' success (design surveys)—initial sources of both qualitative and quantitative data to know where instructors stand in terms of pedagogy, and (3) build a circle of feedback for one course (focus groups)—to create room for initial sharing of potential teaching practices.

For this proposal, after the data collection is completed, (1) we will perform thematic analysis for all the team-lead written reflections and the focus groups data to identify themes related to teaching and learning strategies implementation, the structure of classroom dynamics, nature of classroom participation, creating a sense of belonging in the classroom, and other opportunities for students' success, and (2) the surveys will be systematically coded using statistical techniques to find patterns, relationships, and trends on instructors expectations for students' success.

Findings

Because we are still in the process of data collection for Fall 2025, we have no findings to report in this abstract. However, we hope to have results to be presented during the conference and also get feedback from participants to move forward with this intervention in terms of its design, expected implementation, and impact on students' success in mathematics.

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Elementary Preservice Teachers' Beliefs about Mathematics and Mathematical Abilities in an Introductory Mathematics Content Course

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Introduction and Background Literature

The U.S. continues to struggle with persistent low performance and declining interest in mathematics (Boaler, 2016; Gouëdard, 2021; Schleicher, 2019), as evident in international assessments like the Programme for International Student Assessment (PISA). Between 2018 and 2022, average PISA results in mathematics declined for the U.S, reflecting not only a gap in mathematical skills, but also a problem related to beliefs and attitudes toward mathematics. Additionally, the 2018 PISA study with a half million students revealed that students' beliefs in the malleability of their intelligence had positive and significant associations with their test scores across 72 countries, including the U.S. (Gouëdard, 2021; Schleicher, 2019; Yeager & Dweck, 2020). Moreover, these associations were stronger when students were taught by teachers who held positive beliefs about their students' abilities (Gouëdard, 2021). These findings highlight the importance of beliefs, both about mathematics and mathematical abilities, in addition to mathematical skills. However, research revealed that students, including preservice teachers (PSTs) often tend to hold numerous non-availing beliefs about mathematics and the nature of mathematical knowledge (e.g., Celik et al., 2018; Muis, 2004). One common belief is that mathematical knowledge is unchanging and is simply received passively from some source, such as a teacher or textbook (Celik et al., 2018; Muis, 2004). PSTs also bring a range of beliefs and misconceptions into teacher education that limit their ability to benefit from instruction (Lloyd, 2018; Pajares, 1993). Hence to design better interventions that can positively impact these beliefs, it is important to first examine closely the beliefs PSTs hold as they enter teacher education, leading to the following research questions. In this study, I define beliefs as "psychologically held understandings, premises, or propositions about the world that are thought to be true" and can be seen as lenses that shape one's perspective on various aspects of the world or as dispositions that guide one's actions (Philipp, 2007, pg. 259).

RQ1: *What beliefs about mathematics and mathematical abilities do incoming elementary preservice teachers bring to their introductory mathematics content course?*

RQ2*: How do incoming elementary preservice teachers' beliefs about their own mathematical abilities align or misalign with their beliefs about mathematical abilities of their future students?*

Theoretical Framework

Interpretivism (Stinson & Walshaw, 2017) provided the lens to understand beliefs of PSTs. Sun's (2015) beliefs about mathematics and mathematical abilities provided the central mechanism for data collection. Sun's (2015) beliefs about mathematics consisted of constructs namely: identification with mathematics, nature of mathematics, and mastery-oriented beliefs (or beliefs about making mistakes). This study adopted two more constructs, namely experiences that affected these beliefs (Boaler et al., 2022), and beliefs about mathematical authority (Wilson & Lloyd, 2000). Beliefs about mathematical ability can be viewed as either malleable or fixed (Dweck, 2006), across two dimensions of one's own abilities and their future students' abilities. Beliefs across the dimension of hypothetical future students' abilities are specific to PSTs.

Data Collection, Analysis, and Methods

Participants were elementary PSTs enrolled in an introductory mathematics content course on number and operation, at a public university in the southeastern U.S. Two data collection instruments, 'Beliefs about Mathematics' and 'Beliefs about Mathematical Ability' surveys were adapted from Sun's (2015) validated Likert scale instrument. I adapted this instrument to suit the current study's requirements by splitting it into two shorter surveys, rewording it as qualitative, and replacing a few items to suit the population of future teachers. Codes from survey responses were determined using open thematic analysis (Braun & Clarke, 2006), done in iterations by revisiting and refining to determine broader themes and to improve robustness of findings.

Findings

Findings indicate PSTs hold both positive and negative beliefs about mathematics. Surprisingly, the theme "past teachers" was related to both positive and negative beliefs. Good experiences with mathematics, love for mathematics, and jobs related to mathematics were other themes associated with positive beliefs, whereas harder concepts, especially Geometry, and pandemic during high school years were themes related to negative beliefs. Surprisingly, regarding RQ2, PSTs held more positive beliefs about their students' abilities than their own abilities. For RQ1, describing their previous experiences with mathematics, one participant wrote "*I always liked math it made me feel smart, but sometime in high school the math problems started getting harder and teachers started teaching less. Not only was this during the Covid-19 pandemic so we were in and out of school but my teachers were tired and burnt out. It became more and more difficult to grasp the concepts and I had just execpted [accepted] that I was bad at math."* This response was first coded as- harder concepts in high school, pandemic, and teachers during pandemic being the reasons for negative beliefs about mathematics. After revisiting and refining codes iteratively, the broader themes of negative beliefs, concepts, covid during high school, and past teachers were determined. Regarding RQ2, one survey question asked participants to describe their thoughts about a hypothetical situation, where they are teaching in a classroom, see some kids struggle with content, and when this concern was shared with a fellow teacher, they respond "Some kids can never do well in math, no matter how hard they try". In response to this scenario, only one participant agreed with this hypothetical fellow teacher's response, while all others disagreed. One PST described "*it's our job as educators to help them [students] believe in their ability to learn"*. Another participant responded, *"This mindset is how kids end up never doing well in math, because nobody else believed in them improving, so they could not believe in themselves."*

Discussion and Conclusion

Findings that PSTs held both positive and negative beliefs about mathematics carries implications for both research and practice. For research, this underscores the need for designing effective interventions that can help PSTs overcome academic challenges in mathematics, thus fostering their positive beliefs about mathematics during their teacher education. For practice, it is important for teacher education programs to provide PSTs with opportunities to reexperience mathematics in a mastery-oriented way by valuing mistakes, encouraging productive struggle, and positioning students as the mathematical authority in the classroom. PSTs holding more positive beliefs about their students' abilities than their own indicate they hold high values for their job as future educators. Teacher preparation programs should build on this strength by nurturing PSTs' mathematical proficiency and encouraging them to see their own growth as essential for enabling their future students' success.

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Development of a BME-focused Global Experiential Learning Program Through Application of Situated Learning Theory

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BRIEF SUMMARY AND OVERVIEW OF BACKGROUND LITERATURE

The Biomedical Engineering Design collaboration (BMED) at Clemson University (CU) in South Carolina and Arusha Technical College (ATC) in Tanzania is centered on innovation of biomedical technologies. The CU-ATC partnership enables international educational opportunities for engineering students, successfully engaging culturally diverse teams and expanding the global experiences and mindsets in the undergraduate engineering curricula at both academic institutions. However, involved faculty recognized a need to: 1) define more uniform competencies and teaching methods across academic partners; 2) offer more opportunities for students to build cross-cultural and practical skills in biomedical engineering design; and 3) support broader inclusion of underserved communities. In response to those gaps, the BMED team developed a new hybrid exchange model that integrates virtual and in-person exchange experiences into its BME-focused global experiential learning program.

Aligned with a pragmatic paradigm, the BMED hybrid exchange model emphasizes learning through social interaction. Therefore, Social Cognitive (Learning) theory,[1] Cognitive Apprenticeship theory,[2] and Community of Practice theory [3-6] were considered as potentially relevant theoretical frameworks. Because community of practice theory emphasizes learning and knowledge sharing as being both situational and participatory within a group that shares a common practice, it provided the most appropriate framework to guide this work. Specifically, we structured our project using Situated Learning Theory (SLT) from Lave and Wenger, [4] which has been applied to design thinking [7] and study abroad [8] programs. Situated learning is a type of experiential learning that emphasizes the importance of learning within a specific context and community, where knowledge is acquired through active participation and social interaction. This theory recognizes that learning is unintentional (termed "legitimate peripheral practice") and situated within authentic activity, context, and culture. SLT in defined by four concepts: i) learning (the skills and knowledge gained as a result of participating in a community of practice); ii) context (the environment within which the situated aspect of learning occurs); iii) novices (the learner and newcomer in the community of practice who will learn from the experts around); and iv) experts (the set of individuals who know about the subject to be learned).[9] Constructs include a community of practice (pertaining to the setting where learning occurs), novice and expert participants of the community and their relationships, and the community activities, artifacts, and identities [4].

SIGNIFICANCE

Our BMED hybrid exchange model is scaled to offer opportunities for American and Tanzanian students to build cross-cultural and practical skills in biomedical engineering design. It addresses the growing need for engineers with skills in biomedical design and innovation to meet the expected 7% growth in biomedical engineering jobs and rapid expansion (9.8% CAGR) of the global medical device market. Technology innovation is a major driver of this growth and technologies supporting healthcare delivery in emerging markets are changing fast. For example, the World Health Organization (WHO) highlights the rising demand for specialized medical technologies and infrastructure, especially in countries with rapidly growing surgery needs, yet low healthcare spending.[10] Similarly, regulatory changes in South Africa and East Africa (Tanzania, Kenya, Uganda, Rwanda, Burundi, South Sudan) are expected to boost medical device sales in those regions. These trends create a strong need for engineering education that includes diverse approaches to problem-solving [11-14] and global skills to support healthcare innovation in regions like East Africa.[15].

Study-abroad programs that combine service-learning or situated-learning are effective for educating innovative, globally-minded engineering students and improving outcomes.[16-18] However, there is well-documented inequality in who can access study-abroad opportunities, which limits participation from students of different socio-economic backgrounds.[19-23] Our new BMED hybrid exchange model is significant because it
enables CU and ATC students to swap global locations and learn from each other, with virtual exchange experiences for a majority of involved students supported by in-person exchange for a subset of the students. This approach is unlike programs focused on local (domestic) locations instead of global locations or study-abroad programs involving U.S. students doing service abroad without a true reciprocal exchange. [19, 24-26]

RESEARCH QUESTION(S), DATA ANALYSIS PROCEDURES, AND SUMMARY OF FINDINGS

Our central research question explores how the new BMED hybrid exchange model can enable international educational opportunities for a broader cohort of engineering students and cultivate a design thinking mindset for innovating BME solutions to global health problems. Aligned with SLT, we defined the context as an international, clinically-embedded BME community of practice in four countries (USA, Tanzania, Germany, France) involving interactions between novice and expert participants and the community activities, artifacts, identities, and relationships. Our over-arching research question was: to what extent, and in what ways, is student engagement in an international clinically embedded biomedical engineering community of practice altered by different types and levels of participation in a BME-focused global experiential learning program?

In Year 1 of this 2-year project, we developed and piloted the new BMED hybrid exchange model providing international practice-oriented learning experience for engineers. Our model integrates virtual exchange experiences for a larger cohort of students supported by in-person exchange for a subset of the cohort. In collaboration with course instructors at CU and ATC

through in-person and virtual meetings, we generated detailed outlines of four existing global health courses and discussed relevant modifications for adding global health education competencies and immersive experiences. We aligned our student outcomes with global health curricula and engineering assessment, including the Consortium of Universities for Global Health (CUGH) framework of defined competencies for global health education [27] and the Accreditation Board for Engineering and Technology (ABET) providing national guidelines for the professional development of biomedical engineers [28-29]. We developed detailed lesson plans for courses and activities, with particular emphasis on embedding students into a community of practice of BME professions and integrating core factors for fostering a "design thinking mindset", including forming interdisciplinary teams that work with users, understanding the problem, sharing creative ideas, taking action, and testing prototypes. Courses included participating in activities that required in-person and virtual engagement and the use of hands-on applications to reinforce students' comprehension of basic design thinking concepts, such as empathy, problem definition, ideation, and prototyping.

We defined a mixed-methods approach to analyze the BMED hybrid exchange model. Data collection and analysis are ongoing using defined indicators (outcomes and outputs) and data collection instruments. We are measuring student development of a global mindset using an existing global mindedness scale [30], which includes survey instruments for the constructs of perceived personal growth, perceived professional growth, perceived cultural growth. We developed additional survey questions to characterize essential SLT constructs, including the context, identities and relationships of community participants, and the community activities pertaining to the learning. We developed interview and focus group protocols for qualitative data collection and developed reflective writing prompts for use in the courses. After gaining institutional review board approval, we piloted the new BMED hybrid exchange experience in summer 2025 involving 12 CU students and cycle 1 is ongoing with involvement of 40+ CU students enrolled in three courses and 8+ ATC students enrolled in one course. Activities involve students in working BME professions at healthcare facilities, medical and engineering research labs, and med-tech businesses in more than 20 facilities across the South Carolina community and 25 international facilities located in Tanzania, Germany, and France.

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High School Student Rankings of Hands-on Activities to Introduce Electrical Engineering During Participation in a Weeklong Residential STEM Camp

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Introduction: The STEM Entrepreneurship Academy (SEA) is a week-long residential summer camp at the University of Alabama in Tuscaloosa that exposes high-school students from Alabama to concepts of science, technology, engineering, mathematics, and entrepreneurship [1]. Over each day of the week-long camp, students participate in workshops facilitated by faculty from STEM associated colleges/departments. These workshops introduce different disciplines, provide hands-on activities to experience each discipline, and connect students with professors and researchers in each field. The intent of this exposure is to increase student knowledge about STEM and entrepreneurship and their interest in pursuing a STEM degree; which offer significant workforce opportunities (higher earnings, lower unemployment) for individuals [2].

Research Question: The specific research question that motivates this study is: What activity did high school students participating in the 2024 SEA report as their favorite after a workshop to increase interest in electrical engineering as a future STEM career?

Methods: A total of 29 students (21 Women, 8 Men) from high schools in Alabama districts (Birmingham City, Hale County, Perry County, Tuscaloosa County, Tuscaloosa City) participated in the 2024 SEA. All students were entering grade 11 (N = 13) or grade 12 (N = 16) in the fall semester after their SEA participation. All students identified as being from a group traditionally under-represented in STEM, with 72% identifying as women and 97% identifying as from an under-represented racial minority (Black or Hispanic/Latino) in STEM.

As part of SEA, students completed a morning workshop led by a faculty member from the Department of Electrical and Computer Engineering (ECE) to introduce them to these disciplines. This workshop included a 25-minute lecture with examples of ECE careers and applications (with focus on health and assistive technologies). Health and physiological sensing activities were selected because recent studies suggested that exposure them increases students' self-efficacy and interest in STEM [3]. After the lecture, students were placed into four groups and rotated through 15-minute activities led by engineering graduate students to use some of technologies that had just been introduced. These technologies/activities included using an ultrasound unit to image skeletal muscle, using a photoplethysmography (PPG) sensor to measure heart rate, blood oxygen concentration along with a pressure sensor to measure blood pressure, using a bioimpedance sensor to measure fluid shifts, and controlling a robot made of soft materials. Each activity aimed to give students a chance to physically use the technologies and explore their generated data from a range of conditions. As examples: ultrasound data was collected before and during muscle contraction while blood pressure was collected before and

after a burst of physical activity. After completing all four activities, students were asked to rank their activities in order of the favorite (1) to least favorite (4) and also to note if this workshop changed their interest in electrical engineering.

Analysis & Results: Overall, 21 of 29 participants completed the rank ordering of the electrical engineering workshop activities. The complete set of rankings for each of the activities is given in Table 1.

Activity	**Table 1:** Number of participant rankings for each activity from 1 (Most Favorite) to 4 (Least Favorite)				
	1	**2**	**3**	**4**	**Avg.**
Ultrasound	7	7	3	4	2.19
PPG + Pressure	7	7	5	2	2.10
Bioimpedance	2	4	10	5	2.86
Robotics	6	3	3	10	2.77

The Ultrasound and PPG + Pressure activities both received the greatest number of rankings as favorite (7 each) and the greatest number as the 2nd favorite (again 7 each). This supports that these were the 2 activities that were most engaging and interesting to the SEA participants. Both activities used sensors that translated physiological data into visual formats (e.g. image of muscle cross section) or health metrics (blood pressure, heart rate) that were easy to interpret which may account for the high level of engagement. The bioimpedance activity had the lowest overall ranking, which may be linked to how this activity was setup. The activity only generated a single numeric value related to fluid shifts, which may decrease overall interest in this technology when students do not have any previous experiences with it to understand it. This frames a potential path forward for future activities and to initially focus on technologies students have previous background knowledge about or can be quickly connected to physiological processes.

Of the 21 responses, 18 completed the section of it this workshop changed their interest in studying electrical engineering. Of those 18 responses, 11 (61%) indicated their interest increased, 5 (27%) indicated no change in their interest, and 2 (11%) indicated their interest decreased. Overall, this suggests that these activities were appropriate at increasing interest in electrical engineering for most of the participants. It is hoped that this increase in interest will result in students applying to attend university and pursue electrical engineering (or other STEM programs), but no data is available at this time to evaluate if this has occurred since the end of the program.

Conclusion: High school students ranked activities using ultrasound instruments, PPG sensors, and blood pressure sensors as their favorite during a short workshop to introduce electrical engineering as STEM discipline. Overall, more than half of participants reported this workshop increased their interest in electrical engineering as a future career.

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The Effectiveness of CASE in Enhancing Science Content in Agricultural Education: A Stakeholder Perspective

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School-Based Agricultural Education (SBAE) programs have long sought to bridge academic rigor and career readiness. The Strengthening Career and Technical Education (CTE) for the 21st Century Act of 2018 (Perkins V) reaffirmed the need to integrate core academics into technical content areas (Edgerton, 2022; National Research Council, 1988). Within SBAE, the Curriculum for Agricultural Science Education (CASE) was developed to support inquiry-based, interdisciplinary instruction that merges agriculture, science, math, and literacy through hands-on learning (CASE, n.d.). The CASE model claims to align with the broader national movement to embed STEM principles into CTE programs to prepare students for complex, technology-driven agricultural systems and careers.

While prior studies have explored teachers' and students' perceptions of CASE (Lambert et al., 2014; Smalley et al., 2023; Wells et al., 2021), limited attention has been given to the perspectives of administrators and the dynamic interactions among stakeholders. Teachers often describe CASE as providing a structured framework for integrating scientific concepts into lessons, while students report that the hands-on, lab-based components help them better understand agricultural systems. However, administrators play a key role in supporting implementation through scheduling, funding, and professional development opportunities. Understanding how these perspectives intersect is essential to evaluating the overall effectiveness of CASE.

The purpose of this study was to examine the perceptions of teachers, students, and administrators regarding the effectiveness of CASE in promoting meaningful STEM learning and preparing students for future science-related careers. Specifically, the study addressed three research questions: (1) How does CASE influence student engagement in SBAE courses? (2) How does CASE affect students' appreciation of science principles and concepts? and (3) How do stakeholder perceptions influence CASE implementation in SBAE classrooms?

Guided by Dunkin and Biddle's (1974) Model of Teaching and Learning, this study employed a qualitative multi-case design (Yin, 2014). Four CASE-certified teachers, 34 students, and two administrators participated across three SBAE programs that represented a variety of community and school contexts. Data were collected through classroom observations, semi-structured interviews, and student focus groups to capture both individual and collective experiences. The Constant Comparative Method (Lincoln & Guba, 1981) and open, axial, and selective coding (Creswell & Creswell, 2023) were used to identify emergent themes. Trustworthiness was supported through triangulation, member checking, and an audit trail, ensuring that findings accurately reflected participants' experiences.

Four central themes emerged from the analysis. Academic integration highlighted how CASE strengthened connections among science, math, and English concepts through applied, real-world learning. Teachers described how CASE reinforced their students'

understanding of complex topics such as soil chemistry, plant physiology, and energy systems. Students, in turn, shared that these lessons helped them make sense of what they were learning in their core academic classes, making school feel more cohesive and purposeful.

Bringing agriculture to life reflected how inquiry-based labs and hands-on experiences enhanced engagement, motivation, and critical thinking. Teachers explained that the structured experiments within CASE created opportunities for students to design, test, and evaluate their own hypotheses. For many students, this approach transformed agriculture from a content area focused on memorization into one rooted in discovery. They reported that engaging directly with agricultural materials, tools, and data deepened their understanding and appreciation of science as a living process rather than a static subject.

The CASE experience represented the balance between structure and flexibility in the curriculum. Teachers valued CASE for its organization, sequence, and alignment with national standards but also noted that some lessons were too text-heavy or advanced for their students' reading levels. These challenges led teachers to adapt or simplify certain materials, which sometimes created tension between fidelity to the curriculum and responsiveness to student needs. Students appreciated the variety of activities but voiced frustration when assignments felt repetitive or overly guided. These experiences emphasized the importance of professional development that helps teachers differentiate instruction while maintaining the integrity of CASE's inquiry-based philosophy.

Community influence underscored how local context shaped perceptions of CASE. Teachers in rural schools or those serving non-college-bound populations perceived the curriculum as highly technical and at times disconnected from local agricultural practices. Conversely, teachers in schools with higher STEM participation viewed CASE as a valuable tool for building academic and career pathways. Administrators observed that CASE courses helped students develop transferable skills such as communication, problem-solving, and collaboration. This finding demonstrates the potential of CASE not only to strengthen agricultural literacy but also to advance broader educational goals within CTE.

Overall, CASE effectively engaged students in meaningful STEM learning through agriculture while also building teacher confidence in science integration. The curriculum supported both student-centered instruction and professional growth for educators. However, its technical language and cognitive load presented barriers for some learners, particularly those with limited reading proficiency or minimal science background. These findings suggest the need for adaptation to local contexts, such as simplifying complex materials, integrating community-based examples, and providing scaffolds that allow all students to access content meaningfully.

This research contributes to the growing body of literature on STEM integration within SBAE by examining the CASE model through a multi-stakeholder lens. It highlights agriculture's potential as a vehicle for STEM literacy and demonstrates how teacher preparation, student readiness, and community context jointly influence successful curriculum implementation. By emphasizing inclusivity and accessibility, this study reinforces the importance of tailoring STEM-infused agricultural education to meet the needs of all learners.

Findings suggest that continued collaboration among teachers, administrators, and curriculum developers will be essential to maximizing CASE's impact on science learning and sustaining its role as a model for inquiry-based agricultural education.

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Examining the Certification Choices of Southeastern Agriculture Teachers in the Curriculum for Agricultural Science Education

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The Curriculum for Agricultural Science Education (CASE) provides a structured, inquiry-based approach to teaching agriculture that emphasizes the integration of science, technology, engineering, and mathematics (STEM) principles in school-based agricultural education (SBAE). Since its development, CASE has emerged as one of the most comprehensive curriculum models supporting STEM literacy through agriculture, aligning with the National Agriculture, Food, and Natural Resources (AFNR) standards and the goals of Perkins V to promote academic rigor and college and career readiness (CASE4Learning, 2023). The curriculum equips teachers with detailed lessons, assessments, and laboratory experiences that help students engage in authentic, problem-based learning. Research on CASE-certified teachers has demonstrated that professional development through CASE institutes enhances educators' confidence in teaching scientific content, strengthens their pedagogical practices, and supports inquiry-based instruction (Nelson et al., 2022; Ulmer et al., 2013).

Despite the model's national reach, the adoption and diffusion of CASE certification remain inconsistent across regions of the United States. In particular, the Southeastern region demonstrates slower growth compared to the Midwest and Western states (Aakre, personal communication, 2024). Prior studies have largely explored the experiences of CASE-certified teachers and their classroom implementation of inquiry-based learning (Bird & Rice, 2021; Lambert et al., 2014; Smalley et al., 2023). However, little research has examined why many teachers choose not to pursue certification or what barriers hinder broader adoption. Understanding these decisions is essential for expanding equitable access to professional development, ensuring science integration across diverse SBAE contexts, and addressing systemic challenges such as funding, administrative support, and program sustainability.

The purpose of this study was to examine the certification choices of agriculture teachers in seven Southeastern states, identifying how interest, perceptions, and barriers influence the decision to pursue or abstain from CASE certification. Rogers' (2003) Diffusion of Innovation (DOI) theory guided the study, providing a lens for understanding how educational innovations are adopted through communication networks, social systems, and perceived benefits. DOI constructs—including relative advantage, compatibility, complexity, trialability, and observability—were applied to understand how teachers evaluate CASE as an instructional innovation. The following research objectives guided the study: (1) describe the demographics of SBAE teachers; (2) examine interests, perceptions, and barriers among non-certified participants; (3) examine the perceptions and barriers among CASE-certified participants; and (4) identify correlations between demographic characteristics and perceptions of CASE certification.

A researcher-developed survey consisting of 62 items was distributed via Qualtrics to 2,421 agriculture teachers in Georgia, Florida, Kentucky, Tennessee, Louisiana, Alabama, and South Carolina. Following Dillman et al.'s (2014) tailored design method, participants received four email contacts across a two-week period. The survey generated 134 valid responses, representing 54 CASE-certified and 80 non-certified teachers (5.5% response rate). The instrument, reviewed by experts for content validity, included Likert-type scales measuring perceptions of CASE, barriers to adoption, and professional motivations. Reliability was established with Cronbach's alpha scores exceeding 0.80 for all constructs. Descriptive statistics and Pearson's correlation coefficients were used to summarize findings and explore relationships between demographics, perceptions, and certification decisions.

Findings revealed several key trends. Non-certified participants frequently reported limited awareness of the CASE program and neutral interest in certification, suggesting a lack of exposure and informational outreach. Over half of these teachers identified cost, lack of administrative support, and summertime commitments as the most significant barriers to certification. Many also cited misalignment between CASE and their state agricultural education standards, expressing concern that certification was not feasible or relevant to their current teaching assignment. Teachers in rural communities reported additional logistical and financial barriers, such as travel distance and limited access to CASE institutes, reinforcing prior studies highlighting inequities in professional development access (Bird & Rice, 2021; Smalley et al., 2023).

Conversely, CASE-certified teachers expressed generally positive perceptions of the curriculum, highlighting its organization, rigorous structure, and support for science integration. Teachers noted that the framework improved lesson planning efficiency, boosted student engagement, and expanded their instructional toolkit for teaching complex scientific concepts. Many participants identified increased content knowledge and stronger professional identity as outcomes of certification. However, some teachers described challenges with maintaining the fidelity of implementation due to costly materials, time-intensive labs, and lack of program-wide support. Even among those who valued the curriculum, selective adaptation was common, as educators modified lessons to fit local needs and resource constraints.

Correlation analyses provided further insights into demographic influences on adoption. Younger teachers and female educators demonstrated greater interest in CASE's inquiry-based model, while older teachers were more likely to perceive incompatibility between CASE and state-level standards. Educators in larger schools reported both heightened motivation and increased financial barriers, reflecting the competing demands of diverse student populations and constrained budgets. These results align with DOI theory by illustrating how personal characteristics, institutional contexts, and perceived innovation attributes collectively shape adoption decisions.

This research underscores the need for targeted recruitment and support strategies to expand CASE participation across the Southeastern United States. Increasing access to funding, providing local training institutes, and improving communication about CASE benefits can reduce adoption barriers. Moreover, integrating CASE principles into pre-service agricultural

education programs may foster early familiarity and confidence among future educators. Collaboration among teacher educators, administrators, and the CASE4Learning Executive Team will be essential to creating equitable pathways for professional certification. By addressing systemic barriers and enhancing teacher support networks, the diffusion of CASE can contribute to sustained improvements in science integration, teacher efficacy, and student learning within SBAE programs nationwide.

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Comparing Barriers and Drivers to Graduate Teaching Assistant Professional Development Across Institutions

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Study Context

The United States Bureau of Labor Statistics (2025) predicted a 10.4% growth of science, technology, engineering, and mathematics (STEM) occupations between 2023-2033. This growth will require an increase in students with STEM degrees. Despite this need, attrition in STEM majors continues to be an issue of concern (Smith &Willison, 2021). Among the reasons students cite for leaving STEM majors many revolve around poor teaching (Gafney, 2005; Smith & Willison, 2021; Stains et al., 2018). In a study by Connely et al. (2016), they found 94% of doctoral students taught at some point during their doctoral studies and nearly half of those students were teaching undergraduates within 5 years of receiving their degrees. Thus, graduate students compose a significant portion of instructors in higher education institutions. Their development could position them as teaching leaders in future academic departments.

Despite this position as developing instructors, GTAs often receive little to no effective teaching professional development (Authors, 2011; Stains et al., 2017). Without training, GTAs tend to use more traditional instructor-led teaching styles (Gafney, 2005) and are unsure how to shift toward student-centered pedagogies (Cooper & Bolger, 2023; Authors, 2009). Though some universities are providing GTA PD (Professional Development), GTA PD varies widely between institutions regarding the presence and quality of professional development (Authors, 2015).

This research study is part of a larger NSF-funded project that sought to understand better why GTA PD is lacking or inconsistent across biology departments in higher education. We hypothesized that there may be barriers to providing GTA PD at the departmental culture level that can limit the increased use of student-centered teaching practices with graduate students (Shadle et al., 2017). We do not yet understand what components of departmental culture are critical in determining the presence and quality of GTA PD offered. As such, we asked the following research question.

> *Research Question*: What supports and barriers do GTA PD facilitators and researchers identify as crucial factors of departmental culture affecting the presence and quality of GTA PD?

Research Design and Analysis

This study was part of a larger Delphi study (NSF ECR # XXXXXX). We utilized a semi-structured interview protocol to elicit examples of cultural supports and barriers of GTA PD within biology departments from a sample of n=35 experts in GTA PD. For this study, we

defined “experts” as individuals who had at least five years of experience as faculty or staff in a biology department, extensive experience as a GTA PD practitioner, or published peer-reviewed research related to GTA PD. Experts were identified based on a curated list of authors on published GTA PD research and a 350-person email listserv from an NSF-funded project on GS TPD. Of the n=49 identified expert participants, n=35 participated in the interviews.

We framed this study using Reinholz and Apkarian’s (2018) modified four frames model for organizational change in academic institutions to understand how aspects of the culture could impact GTA PD. The four frames in this model are areas of departmental culture that can affect change: people, power, structures, and symbols. Reinholz and Apkarian (2018) posited successful change in academic departments needs to reflect and influence all four of the above frames. Our interview protocol was structured to uncover elements in each of the four frames that could affect GTA PD. The interviews were recorded via Zoom to capture transcripts. In the first round of coding two research team members deductively coded the interview data for supports and barriers to GTA PD in biology departments. In the second round, the four frames were used as an analytical tool to re-code and classify each barrier and support as a particular component of the department’s culture. Finally, the data were coded inductively within each frame to identify frequencies and commonalities across themes and within each of the four frames. In this proposal, we focus on sharing the most prevalent codes.

Summary of Findings

Initial data analysis involved identifying the supports and barriers to GS TPD. This led to the identification of 64 supports and barriers in the data. These were categorized into 36 supports and 28 barriers. These codes were also reclassified into each of the four frames, people, power, structures, and symbols. Of the supports, 41% were coded as structures, 33% as symbols, 15% as people, and 11% as power. Support codes included codes such as mandatory GTA PD course, teaching experts in the departments, vision, and administrative support. Barrier codes included codes such as lack of time, research priority, lack of education research faculty, and active faculty resistance.

Significance of Research

Though there is research on supports and barriers to GTA PD, previous studies have not compared those challenges across many institutions using the expertise of researchers and GTA facilitators. For instance, Couch et al. (2024) studied fourteen departments in only three institutions and Shadle et el. (2017) studied supports and barriers to GTA PD in departments at two universities. Though Shortlidge and Eddy (2018) conducted a national sample of n=338, their study focused on the perspective of PhD students, whereas our study delved into the perspectives of researchers and GTA PD facilitators. Sadera et al. (2024) conducted a scoping review of the literature on supports for GTA PD, but this review did not address barriers. By using a broad lens, this study, when embedded in the known research provides a clearer picture of the landscape of supports and barriers departments face when implementing GTA PD that can be used to support GTAs in their instruction and impact student learning.

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Intersectional Experiences and Recommendations from Undergraduate Muslim Students for Biology Courses

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Background and Significance of Research

In biology education, creating a learning environment where all students feel supported and able to engage fully is widely recognized as essential. While significant attention has been given to support biology students from racial and ethnic minorities, women, and other marginalized groups (Miles et al., 2020; Wilkins-Yel et al., 2019), religious identity is often overlooked. This oversight is particularly concerning for Muslim students, who frequently face stigmatization based on their religious identity in educational institution settings (Abu Khalaf et al., 2023; Salinas Jr et al., 2022). This stigmatization can present in various forms, such as discrimination (Ahmed et al., 2011), social exclusion (Seggie & Sanford, 2010) and microaggressions (Hodge, 2020). Muslim students also experience challenges adhering to their religious practices in college, such as maintaining prayer obligations within course schedules or observing Islamic holidays (Chen et al., 2019). These negative experiences also intersect with other identities, such as gender, where Muslim women may face both religious and gender-based discrimination more often than men (Aroian, 2012; Seggie & Sanford, 2010). Additional identities such as ethnicity, country of origin, or immigration status can also exacerbate stigma (Abu Khalaf et al., 2023; Chaudry, 2021). Consequently, Muslim identities in the US have become "racialized," meaning they are socially constructed and perceived through racial and cultural lenses rather than purely religious or spiritual ones (Ali, 2019; Salinas Jr et al., 2022).

Beyond these broader obstacles, Muslim students may face unique challenges in biology courses; challenges that are less common in other college settings or in society at large. Some biology topics can appear to conflict with religion (Barnes et al., 2017; Barnes & Brownell, 2017), and active learning in introductory biology has been found less inclusive of religious students (Henning et al., 2019). Our preliminary research with Muslim students who do not visibly display their identity (i.e., women who do not wear hijab and men) also showed Muslim identity was salient during peer interactions, yet biology culture discouraged religious discussion (Edwards et al., *under review*). They often concealed their religious identity due to anticipated stigma. While this work highlights peer interactions, little is known about Muslim students' broader experiences and sense of belonging in biology, particularly when their religious or racial identity is visible. This study seeks to deepen understanding of how intersectional identities shape Muslim students' experiences and belonging in biology, with a focus on women. Findings from this research can inform more culturally competent teaching by acknowledging religious diversity, encouraging dialogue, and respecting students' identities in biology courses.

Research Design and Data Analysis Procedures

This study is conceptually framed within *the intersectionality theory* (Cho et al., 2013; Crenshaw, 1997). We examined how multiple social identities (i.e., religion, gender, race/ethnicity) intersect to shape students' experiences in their biology courses and science

identity (Hazari et al., 2013). Intersectionality recognizes that educational settings are influenced by broader social and historical contexts of inequality, such as racism, sexism, and other forms of discrimination, that shape students' experiences and opportunities (Cho et al., 2013).

In Fall 2024 and Spring 2025, we recruited self-identified Muslim undergraduate biology students who had previously consented to follow-up interviews in earlier survey studies of biology students. 12 women were interviewed for an average of 50 minutes. Using semi-structured interviews, participants were asked questions about their experiences in biology courses resonate to their Muslim identity (e.g., *"Can you describe any experiences you've had in biology classes that felt relevant to you as a Muslim?),* how their intersecting identities shape their experiences in biology courses (*"Please reflect on your own identities, and how your experiences might differ from those of other Muslim students with identities different from yours?"),* and their suggestions for improving biology classroom environments for Muslim students. We used the constant comparative method across coding cycles to build themes that represent students' experiences. We adopted an inductive approach that involved open coding of 4 transcripts, followed by three other iterative coding cycles. During each cycle, researchers reviewed an additional 4 transcripts. We also incorporated team feedback and invited 2 additional undergraduate researchers to do blind coding for segmented quotes and calculate inter-rater agreement.

Findings

RQ1. How do Muslim students experience treatment, belonging, and identity management in biology courses, especially when their religious identity is visible?

Students reported experiencing or witnessing marginalization tied to their intersectional identities, including implicit bias, microaggressions, and exclusion that undermined belonging. Some described differential treatment from instructors linked to visible markers of a Muslim woman's identity (e.g., hijab, niqab). Instructors also occasionally expressed disrespect toward religion through explicit remarks (e.g., insulting God or faith) or implicit comments (e.g., sarcasm, passive-aggressive jokes). Students further noted concern over how they were perceived based on visible or assumed identity markers (e.g., being Muslim, wearing a hijab, ethnic appearance, being Shia). This anticipation shaped how they interacted, disclosed identity, and navigated academic and social spaces.

RQ2. How does biology content relate to Muslim students' religious beliefs and spiritual reflection?

Students described how learning biology content (such as anatomy, physiology, genetics, microbiology, and embryology) can support, affirm, or enhance their religious beliefs, spiritual reflection, or appreciation for divine creation. For example, three participants expressed how that specific biology concepts deepened their awe of creation and strengthened their faith in God (Allah). Two others also recognized an overlap between biological knowledge and Islamic teachings, particularly the content in the Quran. Two other students can also apply biological knowledge to engage with religiously influenced views on ethical topics like abortion or evolution. Some Muslim students, however, find topics such as evolution and genetic modification to be difficult to engage with, due to perceived conflicts with their beliefs or values. These challenges may stem from content that seems to contradict religious teachings or ethical concerns grounded in religious worldviews.

RQ3. What changes do students recommend for making biology education more inclusive for Muslim students?

Students mentioned that acknowledging religious diversity, inviting dialogue, respecting their religious identity, integrating religion and biology when appropriate, and providing specific accommodations would create a better experience for Muslims in biology courses. One student suggested instructors could provide verbal or written cues to acknowledge religious diversity or signal openness to multiple perspectives. Some students also described unmet or unspoken needs for classroom accommodations during specific religious practices (e.g., fasting in Ramadan), which suggests opportunities for instructors to improve in supporting students' religious observance of holidays.

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Department Cultural Supports and Barriers for Implementing Biology Graduate Student Teaching Professional Development: A Delphi Study

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Background & Significance

Two highly influential *Talking About Leaving* studies (Seymour & Hewitt, 1997; Seymour & Hunter, 2019) found that one of the main reasons STEM students switch from science to non-science majors was because of a perception of poor teaching in introductory science courses. At many institutions, graduate students (GS) teach most (if not all) small discussion or laboratory sections affiliated with large science lecture classes (Sundberg et al., 2005). Undergraduates in these small sections may have more positive relational interactions with GS than with a faculty member (Author, 2012). Thus, quality GS teaching in introductory science is likely another critical component of undergraduate student satisfaction, success, and retention in the major. Yet, there has been much less focus on Teaching Professional Development (TPD) for GS compared with faculty (Author, 2011; Author, 2016). Just as faculty TPD has been promoted as an important lever for change in undergraduate science teaching reform, GS TPD can advance the use of effective teaching practices by GS and the perception of instructional quality by undergraduate students (Hughes & Ellefson, 2013). Accordingly, GS TPD has been acknowledged as a strong lever for promoting effective use of evidence-based instructional practices by GS to promote undergraduate STEM student learning and retention (Levers for Change, AAAS, 2019).

Changing teaching and learning practices is not easy, with the success varying widely among departments and institutions (Henderson et al., 2012; Stains et al., 2018). Many change theorists explain these differences through the lens of culture and the reality that pedagogical change is embedded within the cultural values and beliefs of individual departments (Reinholz et al., 2019). To change practices, you have to change values and beliefs, and the most logical place to effect these changes is at the institutional level of the department (Kesar, 2018). Given this, to understand how to change pedagogical practices institutionally, it is critical to first learn how departmental culture is related to teaching and learning practices and development. As part of an NSF-sponsored research study, we focused on the departmental culture as a critical unit of change for offering TPD to GS. This led to the following research question:

Research Question: What characteristics of biology department cultures support or hinder the implementation of graduate student teaching professional development (GS TPD)?

Research Design & Procedure

Research Design: To answer this research question, a Delphi research design was chosen. A Delphi study seeks consensus among a group of experts through a rigorous process of iterative data collection and refinement (Green, 2014). In Delphi studies, the expert sample generates, refines, and ranks key components around the issue of concern. *Expert Sample*: For our study, we sought individuals who were experts on GS TPD within a biology department context. We defined an expert as an individual who had at least five years of experience as staff or faculty within a biology department and who either had extensive experience as a practitioner of GS TPD or had conducted and published peer-reviewed research related to GS TPD. We identified these experts from a curated list of published literature on GS TPD maintained by an Author as well as from a 350-person listserv from an NSF-funded project on GS TPD with which the authors on this proposal were affiliated. An initial sample of n = 49 experts was selected for participation in the study. *Overview of Delphi Rounds*: For the first round of our Delphi study, we generated a list of the supports and barriers to offering departmental GS TPD through a 1-hour semi-structured interview protocol with our expert participants. After themes from these interviews were coded, experts were asked to rank the importance of each theme to offering GS TPD (Delphi Round #2 Survey) and then reflect on the consensus rank (explained further below) and re-rank the cultural components as desired (Delphi Round #3 Survey).

Analysis & Findings

Delphi Round 1 Interview Protocol and Analysis: As noted above, the purpose of the first round of a Delphi study is to generate a comprehensive list of the key components of the complex issue of interest; for us, this was the cultural components that might serve as barriers or supports for the implementation of GS TPD in biology departments. For our study, four researchers reviewed the transcripts of the expert interviews and used inductive content analysis to generate codes associated with their perceptions of the barriers and supports. From this initial list, the four researchers then reorganized and reduced the data to a parallel set of n = 30 barriers and n = 30 supports. A secondary round of coding utilized the Reinholz & Apkarian (2018) departmental culture taxonomy as an analytical framework to categorize each of the 30 barriers and supports as components of a department's: 1) structures (concrete and formal aspects of a department's cultural environment); 2) symbols (abstract and informal aspects of a department's cultural environment); 3) people (the individuals within a department); and 4) power (the interactions between those individuals as mediated by position and power).

Delphi Round 2 Survey Protocol and Analysis: A survey was constructed from this list of 30 barriers and 30 supports for departmental GS TPD to send to the same group of experts to rank their importance. To analyze these data, we took the mean value of the experts' Likert rankings for each barrier and support. We then used these means to rank all 30 cultural supports from most important to least important and all 30 cultural barriers from most significant to least significant.

Delphi Round 3 Survey Protocol and Analysis: In order to reach an expert consensus rank of both barriers and supports, a second survey was distributed to our expert sample. The ranked results of the supports and barriers from the Round 2 survey were provided to the participants. They were asked to review the ranked list and make any adjustments that they felt were appropriate, moving support/barrier items either up or down in terms of importance and/or significance in departmental cultures.

To determine the consensus level of the final ranked support and barrier component lists across all of the expert participants, we calculated Kendall's W. Kendall's W is a common calculation to determine the statistical alignment of experts' agreement of ranks in Delphi studies. For the list of cultural supports, we calculated a $W = 0.648$, $X^2 = 451.051$, $p < .001$. For the list of cultural barriers, we calculated a $W = 0.776$, $X^2 = 562.815$, $p < .001$. These values show moderate to strong agreement within our expert sample, both with strong statistical significance. One way to interpret this data is that, for cultural supports, our experts ranked lists were in approximate 65% agreement, and for cultural barriers, our experts' ranked lists were in approximate 78% agreement. Given these results and the significant time that our participants had already contributed to the study, we decided to cease additional data collection at this point.

Although we are still looking at trends across this data, we do note certain qualitative trends: 1. People/Power cultural components seem to be over-represented as dominant cultural barriers, as six of these items were ranked in the top ten of our expert participants' consensus lists; 2. Structural components of culture appear to be less significant barriers to the implementation of GS TPD, as determined by our experts; 3. The Symbols component was the top barrier, as ranked by our experts; 4. The top nine ranked barriers were either a People Power or a Symbol.

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Using Reflection Journals to Improve Undergraduate Biology

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SIGNIFICANCE:

The purpose of our study is to understand the role that student attitude has on the student experience in STEM (Science, Technology, Engineering, Math) classrooms. By increasing the relevance of the subject material to students, we propose that this will increase the student sense of belonging in the course, increase STEM literacy, and increase student retention in CAS classrooms. The study's insights could influence educational curricula in higher education, shaping the development of course structures and proceedings within higher education leading to an improvement of educational experiences in STEM.

BACKGROUND:

This study focuses specifically on taking student learning beyond textbook knowledge of the STEM disciplines by integrating creativity and ingenuity, increasing societal context of material, and including ethically based reasoning into content-based learning. The goal of this project is to test the pedagogical active learning strategy of journal reflection usage in the classroom with the purpose of better preparing students to become professionals and citizens by empowering them to connect STEM knowledge to solving today's societal problems.

The National Research Council (NRC) has approved funding for several nationwide projects over the past twenty years dedicated to understanding what influences how students learn. These projects conclude that students who are able to see the real-world application of their classroom experience are more engaged and have a more positive attitude regarding learning the material.[5] A study by Hansen and Birol[2] of student attitudes showed a positive correlation between student performance and attitude. As students progressed through the 4-year biology program, the curriculum courses became more discipline specific and focused on real-world application. The overall attitude and engagement of the students increased as they began to see the significant implications of the classroom material, thus demonstrating that student perceptions of the importance of learning are highly correlated to attitudes in the classroom. Merging student interests with the curriculum and classroom experience can enhance student engagement and result in an increase of cognition and retention.[3,4]

METHODOLOGY:

Overall methodology: The methodology implementation occurred in the laboratory setting of introductory biology courses. Students completed a pre-survey during the first week of the semester. A total of 4 reflection journal prompts were given to students to complete throughout the semester. The same survey (post-survey) was given to students during the last week of the semester.

Survey: A modified version of the Colorado Learning Attitudes about Science Survey (CLASS)[6] was used to measure student attitudes. CLASS is specifically designed to test the students' understanding of what counts as knowledge, how society shapes scientific knowledge, how context shapes discovery, and how innovation and technology affect society. Modifying the questions to pertain specifically to BY123 allows us to gain a better understanding of how well our students are understanding the material as well as their attitude toward the learning experience.

Classroom Intervention: Reflection Journal Assignments

The reflection journal assignments cover the four course modules. These topics are the same for both groups and result in students reflecting on topics that students generally have a difficult time applying the details of the topic material to the real world. The journal questions were validated by interviewing graduate teaching assistants, lecture instructors, and students who have already completed the biology course to ensure the prompts provide enough guidance for students.

Data Analysis

a. Quantitative data will be analyzed with the statistical software, SPSS, utilizing a repeated measures t-test, under the assumption that the data fits the numerical representation required to run the t-test.

b. Qualitative data is currently being analyzed utilizing Braun and Clarke's (2022)[1] thematic analysis with an inductive method. In the inductive analysis, the data is coded without trying to fit the themes into a pre-existing coding frame or the researcher's preconceptions about the research.

RESULTS: Both groups experienced a shift in attitude towards learning biology. However, the experimental group, who received the guided prompt, showed a greater shift. The act of guiding them through the process of definition recall to application allowed students to put together topics in new tangible way. This study demonstrates that simple but deliberate modifications of methodological approaches teaching, such as the use of journal reflections, by instructors can have significant impacts on their students' approach, attitude, and application of textbook knowledge to create more well-rounded individuals.

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Framing Teaching Culture:
A Snapshot of Mathematics Departmental Teaching Culture

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Project Significance and Background Literature

The teaching culture within an academic department is "hard to define, understand, and measure," yet plays a critical role in departmental growth (Reinholz & Apkarian, 2018, p3). Changes in departmental teaching culture have the potential to improve instruction and learning, which in turn can positively impact student learning and persistence, especially within STEM fields (Couch et al, 2024; Henderson et al., 2011). Departmental teaching culture can also be leveraged as a metric through which educational reform can be guided and measured (Lau et al., 2022). Furthermore, teaching culture can be used as an evaluative tool for assessing teaching effectiveness (Dennin et al., 2017).

Despite the utility of teaching culture in departmental change initiatives, research examining departmental teaching culture is relatively inconsistent in both how teaching culture is operationally defined and systematically measured. A large proportion of the research relies on implicit characterizations of culture that draw on everyday language rather than from rigorous and established theoretical frameworks (Mohr et al., 2025). Without a clear definition of culture, these change initiatives leave little room for generalization to other contexts. This minimizes the potential for research in this domain to have broader impacts for institutional change.

This presentation seeks to address this gap by using an established framework – Reinholz and Apkarian's (2018) Four Frames model – to characterize the teaching culture of a mathematics department in the Southeastern U.S. This model uses four interrelated frames – *structures*, *symbols*, *people*, and *power* – as a lens through which to obtain a snapshot of culture. *Structures* refers to the roles, responsibilities, practices, routines, and incentives that organize how people interact. *Symbols* refers to the cultural artifacts, language, knowledge, myths, values, and vision that department members use to guide their reasoning. *People* refers to the uniqueness and diversity of the individuals in a department with respect to their goals, agency, needs, and identities. Finally, *power* refers to how interactions between people are mediated by status, positioning, and political coalitions (Couch et al., 2024). The Four Frames model serves as a powerful methodological tool that can be leveraged not only to obtain a snapshot of a department's teaching culture, but also to facilitate targeted transformation within a department.

We addressed the following research question: *How do math instructors perceive the roles of structures, symbols, power, and people within a math department's teaching culture?*

Methodology

Data were collected from focus group interviews conducted with math instructors at an R2 university in the Southeastern United States. During each one-hour focus group, participants reflected on and discussed results from a prior departmental survey on teaching culture. Discussion centered around perceptions of three central themes: relatedness, competence, and autonomy of the department with respect to teaching. For each theme, participants were shown preliminary findings from their department's survey responses and prompted to discuss how their department's teaching culture could explain the findings. Then, additional data summarizing their overall college's responses to the same survey question was displayed, with prompting for comparison with the mathematics department's data.

Data analysis was conducted by a team of six researchers. After cleaning the focus group transcripts, each transcript was deductively coded by a researcher using the Four Frames model (Reinholz & Apkarian, 2018). After this initial round of coding, the team discussed difficulties and revised the codebook to include more robust examples and details. Then, each coded transcript was reviewed by a second researcher, with revisions made where appropriate to ensure consensus across the transcripts. Finally, two researchers inductively coded each of the resultant four frames, focusing on identifying prevalent themes within each frame.

Summary of Findings

We will present common themes from the focus group interviews, organized along the Four Frames: *structures*, *symbols*, *people*, and *power*.

Focus group participants reported on a variety of departmental *structures* which impact instructors' teaching roles within the department, including time constraints. Instructors highlighted a lack of time to plan for their courses, contributing to a lack of autonomy and control. Jo, a tenured faculty in mathematics education, reported her colleagues' course schedules are often "not finalized until ... a week or two before the semester begins ... [sometimes] even later than that." The lack of preparation time before the first day of class resulted in instructors feeling rushed to prepare for their courses.

A common *symbol* reported by members of the mathematics department which impacts their teaching was the nature of mathematics. The nature of mathematics refers to perceptions about what mathematics is and how mathematical knowledge is discovered or created. Some instructors described their perspective on the nature of mathematics and how it guides their teaching. For instance, Cathleen, a tenured faculty, described mathematics as "more like music and art than ... the other sciences." Therefore, Cathleen teaches mathematics in a similar way to how she would teach music, as a "skill building discipline."

One way the uniqueness and diversity of *people* in the department was highlighted was via differences in teaching assignments. Dorothy described the mathematics department as having an "incredibly wide range of different mathematical disciplines that people are working in" such as "algebra, statistics, education, [and] combinatorics." This naturally results in instructors teaching a broad range of courses. For instance, Spencer, who teaches theoretical math courses, described the content as "very difficult ... to teach" and it being "very challenging to get across certain

material to students." Therefore, sticking to pedagogical suggestions from instructors teaching general education mathematics courses may not be effective for Spencer.

A lack of autonomy due to power differentials between faculty based on position and experience emerged as an aspect of *power* during the focus groups. One full-time temporary instructor (FTT), Emmy, described FTTs as unable to "serve on committees or do research work or anything." The power differential between FTTs and tenure-track faculty was further exacerbated by FTT's lack of instructional autonomy. For example, Emmy described FTTs not being "voting members of the faculty" and not being "decision makers, but ... get a lot of decisions made about [them]."

Implications

This study examined math instructors' perceptions of their departmental teaching culture through the four interrelated frames of *structures*, *symbols*, *power*, and *people*. Such a snapshot of a department's current teaching culture can be leveraged to individualize future change initiatives to meet the unique needs of the department. For instance, a change initiative in this department would need to require minimal time commitment in order to be responsive to the structural time constraints of instructors (Bleiler-Baxter et al., 2021). This snapshot also establishes a baseline measurement of departmental teaching culture that can be used to assess the effectiveness of a change initiative. While these findings are unique to the studied institution, they could serve as a roadmap to guide other institutions in characterizing departmental teaching culture within their own context. Further, the stories of these instructors may resonate and inspire other instructors, promoting relatedness and collaboration across institutions.

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Implementing Plan-Do-Study-Act Cycles to Address Problems of Practice in Secondary Mathematics Teacher Preparation

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Introduction and Background Literature

Quality mathematics instruction is becoming central to the development of the STEM workforce, yet many high schools struggle to fill mathematics teaching positions (Malkus et al., 2015). In addition, nearly 1 in 7 beginning teachers leave the teaching profession after the first year (Ingersoll et al., 2014). The attrition rate for beginning teachers, however, is associated with aspects of teacher preparation (Ingersoll et al., 2014). Thus, the need for recruitment and retention of mathematics teachers (Ingersoll et al., 2014; Malkus et al., 2015) coupled with quality mathematics instruction (Banilower et al., 2018; Ingersoll et al., 2014; Markow et al., 2013) is becoming increasingly relevant. To address these issues, a national partnership was launched in 2012 to address persistent challenges in secondary mathematics teacher preparation by combining improvement science methods with a networked improvement community (NIC) design (Bryk et al., 2015; Author, 2020). A NIC is a structured partnership team that brings together institutions committed to solving a shared problem of practice through collaboration and evidence-based approaches (Martin & Gobstein, 2015). The national partnership consists of 19 state or regional partnership teams that include 43 secondary mathematics teacher preparation programs and their affiliated school partners. Grounded in the AMTE Standards for the Preparation of Teachers of Mathematics (2017) and related Guiding Principles (Author, 2020), the national partnership brings together local partnerships of mathematicians, mathematics teacher educators, school personnel, and other stakeholders engaged in preparing future secondary mathematics teachers. Thus, a primary goal of the national partnership is to prepare teachers to provide quality mathematics instruction and grow secondary teacher preparation programs.

One way to enact this change is through small, incremental changes facilitated by a PlanDo-Study-Act (PDSA) cycle. Based on an identified problem of practice, each team uses the PDSA framework to *plan* an intervention, *do* the intervention, *study* its implementation, and *act* upon those results for a subsequent iteration (Bryke et al., 2015). Specifically, each NIC in the partnership uses PDSA cycles to facilitate continuous improvement of their teacher preparation programs, and each is focused on a topic chosen by the NIC. The data generated through these iterations collectively contribute to broader program transformation. The problems of practice studied by each NIC provide insight into what teacher preparation programs are growing and improving on. Thus, we sought to investigate the question: *What trends are present in the problems of practice NICs involved in a national partnership address using PDSA cycles?* To investigate this, we created and analyzed topic patterns within a database of each PDSA cycle submitted by NICs involved in the national partnership.

Methods and Data Collection

Each NIC involved in the national partnership submitted PDSA cycles as part of an annual reporting process. This annual report documents their progress and includes a driver diagram, which specifies the overarching goals of a NIC's work. These goals are then broken into smaller, actionable components which are addressed through PDSA cycles, also included in the annual report. Reports were collected for each year between 2020-2024. In total, 117 PDSA cycles were collected. To compile these, a database was created. The database features three key components: *What* smaller problem each team addressed, *How* the problem was addressed, and the broader *problems of practice* related to partnership goals. The *what* and *how* aspects of the PDSA cycles were taken from the specific components of the cycles themselves. Then, to determine the broader problems of practice, the *what* components were coded using open thematic analysis (Braun & Clarke, 2006) by two researchers. Some example codes were recruitment, retention, candidate pedagogical knowledge, clinical experiences, growing partnerships, and departmental collaboration and equity. Any code disagreements were reconciled amongst the research team. Some PDSA cycles addressed multiple aspects, and were coded accordingly. Further, the problems of practice were analyzed by determining themes and relationships between their occurrences in PDSA cycles. Graph theory was used to visualize the relationships and interconnection between problems of practice. This also helped us visualize the interconnectedness of national partnership teams in their improvement efforts.

Results

As a reminder, our research question is: *What trends are present in the problems of practice NICs involved in a national partnership address using PDSA cycles?* Preliminary results indicate a myriad of problems of practice studied using PDSA cycles. Recruitment was the most commonly studied topic among PDSA cycles, with 56 code occurrences. For example, one PDSA cycle coded as recruitment was focused on creating a concept for a recruitment video. To address this, the NIC collected data from colleagues to assess the clarity of concept and purpose of the recruitment video then brainstormed potential outlets for streamlining and sharing the video. Recruitment was most commonly paired with retention (4 counts), growing partnerships (3 counts), develop program structure (4 counts), and equity (3 counts). Equity was coded 30 times and was interconnected with 6 other codes. For instance, one PDSA cycle's goal was to clarify expectations between mentor teachers and mathematics teacher educators regarding teacher candidate's implementation of equitable teaching practices. To address this goal, the NIC sought feedback from mentor teachers, school administration, and teacher candidates. This was coded as both equity and clinical experiences. In addition, equity was coded alongside other codes including candidate pedagogical knowledge (14 counts), departmental collaboration (6 counts), clinical experiences (3 counts), and recruitment (3 counts), develop program structure (2 counts), and growing partnerships (1 count). Interestingly, the only codes that equity was not paired with were retention and building community. Building community was identified 5 times, but was studied in isolation from other topics. Addressing this problem of practice included designing a club, small events, and a webinar. Another example of a code that was consistently coded in tandem with other codes was Candidate Pedagogical Knowledge.

Candidate Pedagogical Knowledge was most often partnered with equity and clinical experiences.

Conclusion

These results tell us about the major themes teacher preparation programs worked on throughout the years 2020-2024. Equity was a major focus of PDSA cycles, yet the focus was embedded within other concepts. In addition, recruitment was the most commonly studied problem of practice. This is in alignment with the goal of the national partnership, which is to prepare teachers to provide quality mathematics instruction and grow secondary teacher preparation programs. Of the 117 PDSA cycles analyzed, it was clear that many of the major problems of practice are interconnected with one another. Implications from this study point to where secondary mathematics teacher preparation programs need additional support.

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A New Framework for Conceptualizing the Nature of Mathematics in Education

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Relevance of the Nature of Mathematics in Mathematics Education

For centuries, people have been pondering deep, philosophical questions about the nature of mathematics (NOM). Over time, schools of thought such as Platonism, formalism, fallibilism, nominalism, intuitionism, and others have emerged, each attempting to answer such questions. Not only is NOM valuable to contemplate at the philosophical level, but it also has practical relevance to the field of mathematics education. One's personal beliefs about NOM are central to their views on mathematics curriculum and pedagogy. According to Ernest (1989a), mathematics teachers' beliefs about NOM are directly connected to their espoused models of teaching and learning mathematics, and these espoused models are directly related to enacted models. For example, one's overall teaching approach (i.e., drill and practice versus problem-solving) may be influenced by their underlying view of NOM. Therefore, if mathematics teachers are to better align their teaching with the tenets of documents such as NCTM's Agenda for Action (1980) and NCTM's Principles to Actions (2014), their underlying views of NOM, which may be held subconsciously and implicitly, need to be made conscious and examined (Ernest, 1989a). Moreover, according to Watson et al. (2021), when students ask, "Why do I need to know _____?" (p. 352), "Every answer to this question is influenced by the answerer's view of the nature of mathematics" (p. 352). These close connections among the philosophy of mathematics, mathematics pedagogy, and student interest in mathematics underscore the value of researching and understanding NOM specifically within the context of mathematics education.

Existing NOM Frameworks and Their Limitations

Within the last several decades, a number of frameworks have emerged to capture student and teacher beliefs about NOM (e.g., Ernest, 1989b; Grady, 2018; Pair, 2017; Grigutsch & Törner, 1998; Watson, 2019). Ernest (1989b) showcased a framework for conceptualizing mathematics teachers' views, consisting of three viewpoints: the *instrumentalist* view, the *Platonist* view, and the *problem-solving* view. Several empirical studies have used or mentioned this framework as a way of conceptualizing the beliefs of both preservice teachers and practicing teachers in mathematics (e.g., Bentley, 2018; Beswick, 2012; Raymond, 1997; Viholainen et al., 2014). In a study focusing on student teachers' views, Viholainen et al. (2014) used an expanded version of this framework, developed by Grigutsch and Törner (1998), to include four broad perspectives: the formalism-related orientation, the scheme-related orientation, the process related orientation, and the application-related orientation.

Although these modern, education-focused frameworks are useful, they suffer two key limitations. First, each component is treated as a holistic view of NOM rather than a single dimension of NOM. This makes it difficult to describe a person's view of NOM if it falls in between categories. For example, if someone's view is part-instrumentalist and part-Platonist within the Ernest (1989b) framework, this could mean they view mathematics as a static, interconnected set of procedures, or as a disconnected body of knowledge.

By having the components of a NOM framework be individual dimensions like *connectedness* or *discovery*, one's view can be more easily described in terms of those dimensions. As a second limitation, these frameworks ignore some key philosophical ideas about NOM, such as whether abstract objects exist, whether mathematics can or cannot be grounded in axiomatic certainty, and whether mathematics is ultimately invented or discovered.

In addition to the two frameworks already discussed, some other NOM frameworks have been developed for mathematics education purposes (i.e., SCOMAS framework (Grady, 2018); IDEA framework (Pair, 2017); Proposed Unified View (Watson, 2019)). Each of these focuses on only a few key aspects of NOM, such as mathematics being primarily an activity, or mathematics being useful, meaningful, or interconnected. Therefore, each suffers the limitation of being too narrow in its scope of NOM.

Developing a Multidimensional Framework of NOM

I use Ernest's (1989b) framework of NOM, which I now refer to as the Ernest Framework, as a foundation for creating a more powerful, multidimensional framework of NOM. To develop this new framework, I conducted a literature review to unearth various possible dimensions of NOM, each adjacent to one of the three components of instrumentalism, Platonism, or problem solving from the Ernest Framework. In the literature review, for each of these three components, I (a) briefly described the relevant viewpoint of NOM from the Ernest Framework; (b) discussed similar viewpoints of NOM as described in the philosophical literature on NOM; (c) used this broader theoretical context to identify various dimensions of NOM; (d) discussed supporting literature from the mathematics education field that either justified or failed to justify the importance of each dimension established in (c); and (e) used this broader mathematics education context to bolster, refine, and finalize the dimensions created in (c). The final NOM framework was defined as the union of all developed dimensions.

Using this methodology yields three notable properties of the new NOM framework: (a) it is grounded within a preexisting mathematics education framework; (b) the discussion of NOM literature around each of Ernest's components incorporates philosophical views of NOM that have long existed; and (c) the discussion of related mathematics education literature helps to pinpoint the most education-relevant dimensions of NOM. By expanding upon the Ernest (1989b) Framework and integrating related philosophical views of NOM with related mathematics education literature, I defined the following six dimensions of NOM as a robust framework relevant to the mathematics education field:

- **Certainty:** The idea that mathematical truth is certain, free of contradictions, and can be axiomatically grounded.
- **Proceduralism:** The view that mathematics is fundamentally a set of rules and procedures.
- **Connectedness:** The view that mathematics is inherently deeply interconnected.

- **Externalism:** The position that mathematics exists external to ourselves, and in particular, external to our minds.
- **Process View:** The view that mathematics is *not* a fixed body of knowledge, but rather a messy human activity.
- **Culture-Dependence:** The view that mathematics is fundamentally a product of culture.

Using this framework, I am in the process of developing a survey to measure how university mathematics teachers and students view NOM along each of these dimensions. Results from the development and implementation of that survey will be used to further refine the framework to be in alignment with how teachers and students view NOM in practice.

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Leveraging AI to Reform Mathematics Interactions

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Artificial intelligence (AI) advancements have dramatically impacted many facets of education, among them how students engage with mathematics. As an academic disruptor, AI presents opportunities and challenges for instructional reform (Rupnow et al., 2020). As AI mediated instructional methods are innovated, it is important to examine their internal coherence and viability under controlled conditions before implementing them in the classroom. This oral presentation will introduce a *proof-of-concept investigation* of such a method, in which students create and refine their own definitions of mathematical objects through dialogue with a large language model (LLM) AI. The inspiration for such a method comes from established literature suggesting a connection between students generating definitions and their deeper understanding of the defined objects. For studies using AI as a dialogue partner, ethical considerations support conducting proof-of-concept studies such as this before investigating AI interactions with a large number of actual students.

Literature Review

This presentation builds on the growing body of research examining how AI can serve as a dialogical support for mathematical reasoning (Fadel et al., 2024; Kasneci et al., 2023). Prior work has explored the capabilities of LLMs to generate mathematical explanations or examples (Gupta et al., 2025), but few studies have investigated how AI-mediated dialogue can foster student-generated mathematical definitions. These dialogues can be useful in developing conceptual understanding (de Villiers, 1998; Edwards & Ward, 2004). This method made use of gaps between students' formal definitions and their intuitive understandings as determined by Tall and Vinner (1981), to engaging students in exploratory activities incorporating refinement of definitions and connections to broader reasoning processes. This action in turn can contribute to students' development of deep mathematical understanding (de Villiers, 1998). From these findings, the method was developed and investigated to examine how iterative interaction with LLMs might support students in creating and refining definitions of mathematical objects during a classroom learning task.

Research questions and data analysis procedures

This study addressed two research questions: (1) Which features of a simulated LLM definition refinement conversation are associated with producing an improved definition? and (2) In simulated LLM definition refinement conversations using a questioning feedback strategy, how is question type associated with the likelihood of an improved definition? The authors acted as participants (i.e. the "students"), systematically generating 216 definition refinements with three popular LLMs: ChatGPT-4, Copilot, and Gemini. The context for the LLM conversations was that of a 10^{th} grade student completing a classroom task focused on developing precision and rigor when creating a definition for a mathematical object.

The task was designed to combine process-focused assessment principles within an LLM conversation to provide opportunities for learning. Each refinement interaction was treated as a unit for analysis. Four factors were systematically varied in the design:

- Mathematical object defined: ray or quadrilateral
- Language model: ChatGPT, Copilot, or Gemini
- Initial definition: three concept-image-based versions per object
- Feedback strategy: agreement/disagreement or questioning

The authors analyzed 646 definition refinements to determine whether each represented an improvement over the prior definition. Improvement was determined based on whether the refinement enhanced the definition in terms of accuracy and precision (Edwards & Ward, 2004; Zaslavsky & Shir, 2005).

Summary of findings

To understand these observed patterns more fully, the authors fit a binomial logistic regression model to the 646 definition refinements. Predictors included mathematical object (ray vs. quadrilateral), initial definition, refinement number (1–3), language model (ChatGPT, Copilot, Gemini), and feedback strategy (agreement vs. questioning). All two-way interactions were considered and reduced using typical reduction methods. The model yielded moderate predictive power (McFadden $R^2 = 0.301$). Three interaction effects were theoretically meaningful and statistically significant: (1) Definition object × language model, (2) Definition object × initial definition, and (3) Definition object × feedback strategy. Below are some key odds ratios revealed by use of the binomial logistic regression model:

- Odds of improvement (OOI) for Ray were substantially larger than for Quadrilateral, controlling for LLM, initial def, and feedback type.
- OOI for Initial Definitions 1 and 2 were significantly larger than for Definition 3.
- OOI for Refinements 1 and 2 were significantly larger than for Refinement 3.
- OOI for Agreement Feedback were marginally larger than for Questioning Feedback.
- OOI for Funneling Questions were significantly larger than for Focusing Questions.
- OOI for ChatGPT were significantly larger than for Gemini.

These findings suggest the following possibilities and avenues for future research:

- Students were more likely to improve definitions of rays than quadrilaterals, a finding consistent across LLM models, feedback types, and refinement turns, suggesting mathematical content complexity matters when designing formative interactions, whether mediated by a teacher or an LLM.
- Improvement was most likely to occur on the first or second refinement, with significantly lower odds of improvement on the final turn. This suggests diminishing returns across all refinement turns, potentially indicating a saturation point where students either run out of actionable feedback or reach a maximal understanding within the limits of the dialogue structure.

- Feedback strategy on its own was not a significant predictor of improvement on its own. However, when considered alongside quadrilaterals, it showed greater odds of improvement, suggesting the complexity of the mathematical object impacted the possible refinement.
- Funneling questions were strongly associated with improvement, producing over 12 times the odds of improvement compared to focusing questions, however it is difficult to determine whether the student understands the definition of ray more fully or if they are playing a language game with the LLM
- Language model choice was a significant factor in shaping outcomes. Students were far more likely to improve definitions when refining with ChatGPT than with Gemini. Copilot yielded intermediate results. This finding cautions against assuming uniformity across LLMs and instead suggests a tool-specific perspective.

Conclusion

This proof-of-concept starts the examination of a possible application of LLM AIs in the classroom. The authors hope to continue examining the possibilities of AI not simply as a tool to help students to develop ideas in the classroom, but ultimately to give them the skillset to learn independently and be critical of knowledge dispensed by AI (Freire, 2000). Future steps will involve evaluating the findings to modify the method before introducing it to students.

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Broadening STEM Communities and Identities

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Introduction, Background, and Significance

Decades of research have established a significant divide between what we know about effective learning and how STEM is taught, particularly in K-20 education [1, 2]. While evidence-based practices like project-based, collaborative, and learner-driven approaches are known to foster deep understanding and persistence, a dominant conceptualization of learning as a linear process of information transmission continues to prevail [3, 4]. This "Transfer-Acquisition" conceptualization is a socio-culturally situated system of ideas that gives rise to sub-optimal practices like long-form lectures and multiple-choice exams. These practices, in turn, limit student engagement, agency, and the very development of a robust STEM identity [5].

A critical, yet overlooked, dimension of this problem is the narrow conceptualization of what constitutes a STEM field. This research reveals that the learning sciences, despite its empirical, data-driven, and design-oriented nature, is often not recognized as a legitimate STEM discipline [6, 7]. Instead, it is commonly perceived as a non-STEM field that simply works with STEM, creating a persistent disciplinary chasm [8, 9]. This misconception is especially problematic in graduate education, where a strong STEM identity is crucial for student persistence and career readiness, yet the absence of this recognition creates barriers for students in the learning sciences [10, 11, 12]. This intellectual and professional marginalization of the learning sciences is directly addressed in this work as a critical problem that hinders the progress of the entire STEM enterprise [13, 14].

Methods

This research is conducted as a critical literature review. The methodology treats the existing body of scholarly work as the primary data source, framing the careful and systematic review of published research as a form of empirical inquiry. The goal of this process is to surface systemic conceptualizations and emergent problems that are not apparent from a superficial reading of isolated studies.

The analysis procedures involve a conceptual synthesis of literature across fields, including STEM identity development [11, 15, 16], the history and philosophy of the learning sciences [17, 18, 19], and project-based learning methodologies [20, 21]. By engaging with this corpus of literature as a dynamic, interconnected text, we identify core concepts, patterns, and contradictions. We then apply a critical lens informed by complex conceptual systems theory to discern how the conceptualization of STEM itself, as a system of interdependent ideas, perpetuates a narrow and problematic view that excludes the learning sciences.

Findings

Our critical synthesis of the literature revealed a series of emergent, conceptual problems that constitute the core findings of this research. These findings are not novel data points from an

experiment, but rather insights into the systemic gaps and contradictions that exist within the STEM education landscape.

The first significant finding is a clear knowledge gap concerning the development of STEM identity within the learning sciences. Our review uncovered a substantial body of work dedicated to understanding identity formation in traditional STEM fields like physics and engineering [16, 24], yet a striking paucity of equivalent research within the learning sciences. This disparity reveals a fundamental disciplinary void that not only limits our ability to foster a robust sense of self among learning scientists but also impedes the progress of both fields by preventing a deeper, interdisciplinary dialogue about what it means to be a STEM professional. This silence in the literature is a finding in and of itself, and it points to a critical area for future inquiry.

Secondly, our analysis revealed a pervasive disciplinary chasm that is rooted in a narrow, exclusive conceptualization of what constitutes STEM. This limited perspective is perpetuated by institutional, cultural, and pedagogical norms that often fail to recognize fields such as the learning sciences as a legitimate, empirical STEM discipline. This devaluing of scientists in various fields (including learning scientists) creates a problematic feedback loop, as the field and its transformative practices are marginalized within the broader STEM community [6, 7]. This conceptual barrier directly contributes to the underrepresentation of these scientists in STEM spaces and hinders the dissemination of evidence-based pedagogical practices that could benefit all STEM education.

Finally, we find a powerful opportunity to leverage project-based learning and real-world impact work as a means to perturb this system and strengthen students' identities as STEM professionals [25, 26, 27]. Our synthesis reveals that authentic, situated experiences are high-leverage intervention points for shifting students' perceptions of themselves and their field. By engaging learners in the kind of impactful, collaborative work that is at the heart of the learning sciences, we can directly challenge and transform the narrow conceptualizations of STEM they may hold. This approach is not merely about teaching skills, but about fostering a profound sense of self as a capable, contributing member of the STEM community, thereby bridging the chasm between the learning sciences and other STEM disciplines.

Conclusion

This research demonstrates that a critical analysis of scholarly literature can serve as a robust form of empirical inquiry, with the potential to yield significant findings in the form of identified conceptual problems. Our findings reveal that the persistent chasm between evidence-based practice and widespread reality in STEM education is not merely a practical problem, but a conceptual one. By embracing a broader, more accurate conceptualization of STEM that includes the learning sciences, we can foster a more holistic and empowering educational ecosystem. This intellectual and disciplinary shift has the potential to lead to the emergence of more equitable and effective practices in STEM education as a whole, benefiting a new generation of learners and advancing the entire STEM enterprise.

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Emergence in STEM Conceptualizations of Learning

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Introduction, Background, and Significance

In the realm of STEM education, from kindergarten through higher education (K20), the way we conceptualize learning profoundly influences our teaching practices and student outcomes. However, these conceptualizations are often complex, interconnected systems that remain largely unexplored and unaddressed in STEM education research. This paper presents an innovative approach to understanding and transforming these conceptualizations using complex conceptual systems theory, with the goal of fostering more equitable, effective, and empowering learning environments across the K20 STEM education spectrum.

Complex systems theory has emerged as a powerful framework for understanding diverse systems across various domains, including STEM education [1,2,3,4]. In the learning sciences and STEM education, complex systems approaches have been applied to examine learning environments, educational policies, and student outcomes [5,6,7,8,9,10,11,12]. However, the application of complex systems theory to the study of conceptualizations of learning remains largely unexplored.

Our research defines conceptualizations as socio-culturally situated and distributed systems rather than purely cognitive constructs [13]. This perspective aligns with work on conceptual metaphors [14,15], which reveals that our thinking is fundamentally structured by deep-seated conceptual systems. In STEM education, educators' conceptualizations of learning shape their pedagogical approaches, assessment strategies, and interactions with students [16,5].

Complex conceptual systems theory, developed through our prior research [13,17,18,19,20,21,22,23,24,25,26,27,28], provides an innovative framework for understanding how interrelated ideas function as complex adaptive systems. This theory describes conceptualizations as complex systems situated in social, linguistic, historical, cultural, and material environments. These conceptualizations consist of thousands of interdependent ideas that self-organize to form unique conceptualizations.

In a key study [13,22], we used complex conceptual systems analysis to uncover two distinct conceptualizations of learning among STEM professors and learning scientists: Transfer-Acquisition conceptualization was prevalent among STEM professors, and the Construction-Becoming conceptualization was prevalent among learning scientists. Each conceptualization was associated with unique sets of practices, providing initial evidence that teaching and learning practices in STEM education emerge from educators' conceptualizations of learning.

Understanding conceptualizations of learning as complex systems is critically important for several reasons. First, it enables characterization of deeply engrained models, beliefs, metaphors, and assumptions that different groups hold about the nature of learning - elements that are often unexamined yet profoundly shape behaviors and practices in STEM classrooms. Second, this

research suggests conceptualizations of learning function in systemic ways with strong emergence - they self-organize to produce particular sets of practices, terminology, cognitive filtering, and values. Finally, problematic conceptualizations appear tightly linked to issues of equity, empowerment, and social justice in STEM education, while transformative conceptualizations align better with empowering and equitable practices.

The ability to systematically analyze conceptualizations around learning at scale across different groups in K20 STEM education has immense potential to expose hidden drivers behind inequality producing tendencies while illuminating alternative conceptual models that foster more empowering practices in teaching, mentoring, and learning.

Methods

This paper is a synthesis of multiple studies in which we employed a mixed-methods approach, combining qualitative analysis of interviews and classroom observations with quantitative network analysis techniques. This methodology allows us to map out conceptual systems and study how they change over time. Key components of our research include in-depth interviews with K20 STEM educators and students, classroom observations across various STEM disciplines, complex conceptual systems analysis using network mapping techniques, and design and testing of interventions to help educators and students shift their thinking about learning.

Findings

Our preliminary findings suggest that K20 STEM educators often use conceptualizations of learning that align more closely with the Transfer-Acquisition model, which may limit opportunities for student agency and generative learning. Practices emergent from this conceptualization were primarily focused on lectures, textbooks, and exams. Educators who use conceptualizations closer to the Construction-Becoming model tend to foster more inclusive and empowering learning environments. Practices emergent from this conceptualization included collaborative learning, project-based learning, design-based learning, tinkering and exploration (productive failure), and student work in real-world contexts. Interventions designed to help educators reflect on and shift their conceptualizations of learning can lead to meaningful changes in teaching practices and student outcomes.

Conclusion

Complex conceptual systems theory offers a powerful new lens for understanding and transforming STEM education across the K20 spectrum. By uncovering the hidden conceptualizations that drive teaching and learning practices, we can develop more effective, equitable, and empowering educational approaches. This research has the potential to revolutionize STEM education by addressing the root causes of educational inequities and fostering learning environments that truly empower all students to thrive in STEM fields.

Moving forward, our research aims to develop a comprehensive typology of learning conceptualizations across K20 STEM education and create and validate assessment tools for identifying conceptualizations of learning among educators and students. We will also design and test scalable interventions for promoting more empowering conceptualizations of learning in STEM education. We believe that it is important to investigate the relationship between

conceptualizations of learning and specific STEM disciplines, looking for patterns and variations across fields.

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Understanding Cultural Dissonance and its Potential to Foster Change in STEM Departmental Teaching Cultures

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Brief Overview of the Background Literature

To transform undergraduate education, individuals need to work within their department to strengthen cultural aspects of teaching and encourage positive changes (Baldwin, 2009). This NSF-sponsored project drew on self-determination theory (SDT; Ryan & Deci, 2017) as a way to frame and assess departmental culture by measuring whether instructors perceive their psychological needs for teaching as being met. As described by SDT, the psychological needs are competence (feeling effective to accomplish tasks related to teaching), autonomy (being able to make independent decisions), and relatedness (strong and caring relationships with others for teaching). When instructors' psychological needs are met, they are more likely to be motivated to use practices aligned with optimal student learning (Stupnisky et al., 2018). Using this theory, instructors' psychological needs can be explicitly explored to understand how they are (or are not) being satisfied in a particular instructional environment. Instructors can *integrate* the values or beliefs of the instructional environment into their own personal beliefs to enact the beliefs and values of the culture of their own volition (Ryan & Deci, 2017). Whereas SDT posits that competence, autonomy, and relatedness are critical psychological *needs* to support task motivation, cultures may not *value* these needs and may not create environments to support them. To capture the importance of an instructor's perceptions of their psychological needs within the broader departmental teaching culture, we also consider the department-level psychological needs for teaching, called cultural needs (Bronfenbrenner, 1979; Ryan & Deci, 2017). We anticipated there could be important (mis)matches between individuals' psychological needs and cultural needs (cultural integration and cultural dissonance), which allowed us to consider perceptions of the department culture to support change efforts.

Significance of the Study & Research Questions

This study is a part of a larger project aimed at fostering a Culture of Learning in STEM departments that are inclusive (support all students in learning; competence psychological need), collaborative (sustain interactions among instructors for teaching; relatedness psychological need), and growth-oriented (instructors continually strive to improve their instruction; autonomy psychological need). In this project, we anticipated a Culture of Learning would be achieved by supporting instructors in strengths-based reflection on their instruction (Henderson et al., 2011; Korthagen & Vasalos, 2005; Machost & Stains, 2023; Murphy, 2024). Therefore, this study considered instructors' perceptions of their reflective practices for each of the dimensions of a Culture of Learning to explore participants' perceptions of integration or dissonance with the culture. We sought to explore this through the overarching question: *How do individuals perceive cultural integration or dissonance in their department for relatedness, competence, and autonomy in reflective teaching practice?* To address this overarching question, we explored two

sub-questions: a) How do individuals perceive satisfaction or frustration for their psychological needs of relatedness, competence, and autonomy in reflective teaching practice? b) How do individuals perceive satisfaction or frustration for their department's cultural needs of relatedness, competence, and autonomy in reflective teaching practice?

Data Analysis Procedures

The participants in this survey study were individuals who teach in the biology, chemistry, geosciences, and mathematics departments at a large R2 Southeastern United States University (n = 78). There were four items that focused on participants' perceptions of whether their psychological needs (relatedness, competence, and autonomy for a total of twelve items) are being met for reflective practices in teaching. The Likert scale for the survey items is 1-5 where a value of 1 Likert scale unit indicates reflecting independently, 3 indicates a neutral response, and 5 indicates reflecting collaboratively with colleagues. For research question 1a, we reviewed how each participant responded to the survey item for their current actions and their desired actions. If the difference between the Likert scale units of their current and desired states was equal to or less than 1, we interpreted this finding to indicate the participant *perceived satisfaction*. If the difference between the Likert scale units was greater than 1, we interpreted this finding to indicate the participant *perceived frustration*.

For research question 1b, this process was repeated to analyze the departmental culture. To address our overall research question, we considered the findings from research questions 1a and 1b. If the participant perceived satisfaction of specific psychological needs at the individual level as well as at the departmental level, we interpreted this as *satisfied cultural integration*. If participants perceived frustration at the individual and departmental levels, we interpreted this as *frustrated cultural integration* since participants have integrated the perceptions of the culture's beliefs, values, and actions into their own and yet are frustrated with the resulting actions. If the participant perceived satisfaction at the individual level but frustration at the departmental level (or vice versa), we interpreted this as *cultural dissonance.* Each of the research questions was addressed using the average response within the department instead of comparing within an individual participant. This analysis summarized how individuals and departments perceive their psychological needs as satisfied or frustrated within their departments. For this proposal, we focus on just sharing the average values of each department due to space limitations.

Summary of Findings

Participants tended to perceive value for their psychological needs of relatedness, competence, and autonomy in teaching. A notable exception to this, however, was for the biology and geosciences psychological need of relatedness for teaching. These departments, did not appear to value collaboration in their reflective practices for teaching. Yet, both the biology and geosciences departments perceived *cultural integration* for working independently on their reflection. At the departmental level, more participants tended to perceive frustration with their department's current reflective practices (but perceived satisfaction at the individual level), which we interpreted as *cultural dissonance.* All four departments perceived value for competence (use of reflection to support the learning of all students) and autonomy (use of reflection to modify their instruction). The findings described in this proposal have implications for understanding how to support departmental teaching culture change by emphasizing the importance of understanding each department's unique context. For instance, based on these data we hypothesize individuals who experience cultural dissonance may be able to act as departmental leaders to support cultural change efforts to transform undergraduate education.

Table 1: Summary of the survey findings for each department

Need	RQ 1: CI or CD	RQ1a: Psychological Needs	RQ1b: Cultural Needs
Relatedness	**CI:** Biology and Geosciences	**S:** Biology, Chemistry, Geosciences, and Mathematics	**S:** Biology, Geosciences
	CD: Chemistry and Mathematics		**F:** Chemistry and Mathematics
Competence	**CI:** Biology, Chemistry	**S:** Biology, Chemistry, Geosciences, and Mathematics	**S:** Biology, Chemistry
	CD: Geosciences and Mathematics		**F:** Geosciences and Mathematics
Autonomy	**CI:** Biology and Geosciences	**S:** Biology, Chemistry, Geosciences, and Mathematics	**S:** Biology, Geosciences
	CD: Chemistry and Mathematics		**F:** Chemistry and Mathematics

Note: CI = cultural integration (pink); CD = cultural dissonance (blue); S = satisfaction (green); F = frustration (orange)

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Teacher Discourse Moves to Support Student Sensemaking During Data Investigations

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Introduction

Effective teachers use instructional strategies that support student sensemaking (Colley & Windschitl, 2016; Fitzgerald & Palincsar, 2019; Li & Schoenfeld, 2019; Stockero et al., 2022). Students engage in sensemaking in the classroom when they have opportunities to draw on their prior knowledge to "figure something out" by building, testing, and revising their explanations (Odden & Russ, 2019a, p. 192). When students engage in sensemaking, they make connections between disciplinary ideas and their own experiences (Windschitl et al., 2018), generate knowledge (Chen & Techawitthayachinda, 2020; Li & Schoenfeld, 2019; Odden, 2021; Odden & Russ, 2019a), and gain greater understanding of disciplinary practices (Fitzgerald & Palincsar, 2019; Li & Schoenfeld, 2019).

Research suggests, however, that the process of student sensemaking is dynamic and fleeting, perhaps only occurring for minutes (Hutchison & Hammer, 2010; Odden & Russ, 2019a). Thus, one instructional challenge for teachers is how to begin the process of student sensemaking and then sustain it (Odden & Russ, 2019a). Teachers' discourse moves (TDMs), the intentional actions a teacher takes to participate in or guide the classroom discourse (Krussel et al., 2004), are one instructional strategy that supports students' sensemaking (Benedict-Chambers et al., 2017; Carpenter et al., 2020; Colley & Windschitl, 2016; Fitzgerald & Palincsar, 2019; Lowell et al., 2022).

Although TDMs to support student sensemaking have been studied in discipline-specific contexts, such as physics or mathematics, little is known about how they function when teachers are teaching in interdisciplinary learning spaces. In these spaces, TDMs need to support students to reach for ideas and practices from multiple disciplines that are often disconnected, both in time and instructional space, from one another in schools. Because of this gap in the literature, this study is situated in the interdisciplinary context of data investigations.

Data investigations are activities in which students analyze data for the purpose of answering an investigative question about real-world phenomena (Bargagliotti et al, 2020; Lee et al., 2022). These interdisciplinary classroom activities require teachers and students to coordinate ideas from mathematics, data science, and the context of the investigation (Cobb & Moore, 1997; Kjelvik & Schulteis, 2019; Wild et al., 2018). Sensemaking is an integral part of data investigations because students are continuously generating ideas from their prior knowledge, connecting them to the data and analysis, and engaging in cycles of critique and judgement (Arnold & Franklin, 2021; Wild & Pfannkuch, 1999).

Supporting student sensemaking during data investigations is challenging for teachers (Elsayad et al., 2024), and so we chose to study how experienced, in-service sixth-grade science and mathematics teachers used discourse moves to support their students' sensemaking. Specifically, we asked the following research questions:

> RQ1: In whole-class discussions, how do experienced mathematics and science teachers use discourse moves to initiate students' sensemaking talk during data investigations? RQ2: How do these teachers' discourse moves sustain students' sensemaking talk?
> RQ3: What kinds of teacher discourse moves end students' sensemaking talk?

Research Context and Methods

The data analyzed in this study were a subset of data from a larger one, the Integrated Data Project (IDP). Data was collected in a large, public middle school in the southeastern United States. For this study, we chose a homogeneous sample (Patton, 2015) of four veteran teachers, two in mathematics and two in science, who had many years of experience (mean=16.5 years). Three of these teachers also held leadership positions, i.e., instructional coach, department head, in their school. As part of the IDP, we video-recorded these teachers as they taught the data investigations "Inventing Data Displays" in mathematics and "How Do Plants Change as They Grow" in science. Both investigations had students creating data displays from measurements they made and making claims about sources of variability in that data.

In our analysis, we used the qualitative data analysis software MaxQDA to code the video recordings. First, we identified those segments in classroom discourse when teachers engaged in whole class discussions. We then looked for segments that resulted in student sensemaking talk (SST). Student sensemaking talk includes proposing a question that needs figuring out or explaining (Odden & Russ, 2019b), connecting phenomena with disciplinary concepts/practices (Benedict-Chambers et al., 2017), engaging in extended explanations (Kapon, 2017), and engaging with others' ideas (Carpenter et al., 2020; Windschitl et al., 2018). These segments, SST episodes, were the unit of analysis. Each episode was bounded by the teacher's discourse immediately preceding the SST, typically a question, and the teacher's discourse immediately following the SST episode. We found SST episodes in all four teachers' whole-class discussions.

We then used a mixture of deductive and inductive coding to characterize the TDMs and the students' discourse during each SST episode. We deductively coded TDMs using descriptions known to support student sensemaking from the extant literature (i.e., Herbel-Eisenman et al., 2013; Tytler & Aranda, 2015; Windschitl et al., 2018), e.g., revoicing, follow up, marking, clarifying. Any teacher utterances that did not fit these descriptions were inductively coded using their functions in the classroom discourse, e.g., asking for observations, asking to make a claim, etc. Students' utterances were inductively coded according to their functions in the classroom discourse, e.g., explains, adds on to an idea, gives evidence. Each teacher and student utterance could have multiple codes.

Student sensemaking is a process where students assemble prior knowledge, identify a gap in their understanding, and then build and critique explanations to resolve that gap (Odden & Russ, 2018, 2019a), and so we used this framework to look for patterns in TDMs across all the SST events.

Summary of Findings

In many SST episodes, teachers used TDMs to elicit students' ideas and begin assembling their prior knowledge. They asked for students' observations by saying "What do you notice?" or asked for their ideas by saying "Why did I have each of you measure?" Students responded by sharing their ideas that the teachers revoiced or asked clarifying questions. These types of eliciting TDMs brought out students' prior knowledge and created a shared understanding of what students knew. They also provided an opportunity for students to reach for prior knowledge across disciplinary boundaries. Assembling this knowledge framework is a necessary precursor to sensemaking (Odden & Russ, 2018). After using TDMs to elicit and clarify student ideas, however, teachers often used subsequent TDMs to change the topic of the discourse, and students often did not fully enter into the sensemaking process.

Fewer SST episodes included TDMs to support students in identifying a gap in their understanding to begin the sensemaking process, although all four teachers used at least one TDM that functioned in this way. Teachers supported students to begin sensemaking by highlighting an inconsistency, saying, "Is my arm span both 12 centimeters and 263 centimeters?" or by highlighting a puzzle, saying, "Do you think they put that [a numbered gap where no data existed] there on purpose or on accident?" Students responded by making claims and beginning to develop explanations. These TDMs helped students see the need for generating explanations about important concepts; for example, explaining sources of variability in their data or explaining the choices, such as the use of scale, that authors make when creating data displays.

It was rare for an SST episode to include TDMs to support students to critique and revise their explanations, the final step in the process of sensemaking. When critique did occur, it was often the teacher who challenged a student's idea using the TDM of pressing. The TDMs of asking a student to revoice an idea or add on to what another student had said occurred rarely. Supporting students to make sense of data is a challenging and complex teaching practice (Elsayad et al., 2024). These findings suggest that experienced teachers use eliciting TDMs and highlighting puzzle TDMs to initiate the sensemaking process, but using TDMs to sustain it is more challenging. This study provides insight into how to assist mathematics and science teachers in using TDMs to support their students to engage in sensemaking during data investigations.

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Make a Good First Impression:
An Analysis of the Learning-Centeredness of Course Syllabi

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Overview of Background Literature

Physical Chemistry (pchem) courses are required for all Biochemistry, Chemistry, and Chemical Engineering majors in their junior or senior year. Instructors teach thermodynamics, reaction rates and dynamics, and quantum mechanics. Prerequisites include derivative and integral calculus, general physics, and general chemistry. Due to the subject matter and prerequisites, students often form a negative impression of pchem before they even enroll.[1] Similarly, students view many STEM classes as being unreasonably difficult and irrelevant to their academic goals. Since students are more motivated to learn if they expect to be successful in a class and if they perceive the class to be useful, it is critical that STEM course instructors to address students' negative perceptions as early as possible.[2]

This can begin on the first day of class. Reading the course syllabus is often the first way that students learn about a course. In addition to being a course contract, the syllabus is also a way for the instructor to convey the value of the course and motivate students to learn more.[3] The contents of the syllabus and the way that the instructor communicates that course information affects students' expectations.[4] A syllabus that shows alignment of course objectives with assessment[5] and explains how the course is structured[6] will improve students' motivation and performance. These and other examples of student-centered course design are considered best practices for an effective instructional approach for all subjects.[7]

In addition to improving students' first impression of the course, a learning-centered syllabus can have two other benefits. First, the process of aligning course goals, objectives, and assessment can lead an instructor to design the whole course to be more learning-centered.[8, 9] A learning-centered syllabus also encourages students to refer to the document often, leading them to read it more thoroughly. Learning-centered, first-day activities, such as a syllabus quiz, can promote syllabus reading also.[10]

Significance of This Research

More than just a list of course policies, a syllabus shapes students' first impression of the course. This is a valuable opportunity for STEM course instructors to address and allay students' fears and motivate students to engage with the course material. Our research reveals shortcomings frequently found in pchem syllabi (and likely in syllabi of other STEM subjects as well) and provides straightforward ways for instructors to improve their students' learning experience by adopting a more learning-centered approach to the course syllabus.

Research Questions

Our purpose for this research was to measure the learning-centeredness of pchem syllabi before and after the COVID-19 pandemic. This analysis reveals ways to modify syllabus components in order to improve their learning-centeredness. We used a previously validated rubric to evaluate the learning-centeredness of syllabi overall and of specific syllabus components.[11] Our research questions were:

1. How do physical chemistry syllabi fall on the content- to learning-centered spectrum?
2. Which specific components of syllabi are more or less learning-centered than others?
3. What effect did the transition to remote instruction during the COVID-19 pandemic have on the learning-centeredness of Physical Chemistry syllabi?

Data Analysis Procedures

We collected pchem syllabi by requesting syllabi from users of a pchem instructor listserv and by searching online for publicly available syllabi. This resulted in a total of 92 syllabi for courses taught between spring 2017 and fall 2019 in the U.S. Most syllabi were from courses taught at large PhD granting universities and most schools were located in the eastern U.S. Most syllabi covered topics that would be expected for a pchem lecture course (thermodynamics, kinetics, and quantum mechanics).

We used the Measuring the Promise rubric, which can be used to measure the learning centeredness of syllabi.[11] This rubric identifies parts of the syllabus that positively or negatively influence student learning in four areas of learning: (1) goals and objectives, (2) assessment, (3) course schedule, and (4) overall learning environment, with subcategories for each. The sum of subcategory ratings places the syllabus on a spectrum from content-centered to learning-centered.

Both researchers teach Physical Chemistry. We followed instructions for rating syllabi given in the Measuring the Promise rubric in order to establish validity and inter-rater reliability. Initially, we rated sample syllabi that accompanied the rubric and discussed any differences in our ratings. We then rated 53 pchem syllabi separately and discussed differences until we reached agreement (within <10% of our overall score and no major differences in subcategory ratings). Each of us then rated half of the remaining syllabi independently.

Summary of Findings

Our evaluation of the learning-centeredness of the pre-pandemic (2017 – 2019) pchem course syllabi revealed that most were content-focused, rather than learning-centered. Most syllabi lacked a clear explanation for the proposed sequence of topics. Syllabi that rated low on the learning-centeredness scale did not clearly define major assessments, did not use a positive or inviting tone when explaining course policies, and did not convey the value of the course.

Education researchers believe that the shift to remote teaching during the COVID-19 pandemic affected how instructors designed and taught their courses.[12-14] To determine if this change was reflected in the course syllabi, we analyzed 23 syllabi used in 2021 – 2022 by the same pchem faculty whose syllabi we analyzed in our previous study. We found that the syllabi

had become more learning-centered, with notable shifts towards learning-centered assessments and communication by the instructor.[15]

This analysis allowed us to identify potentially useful ways for instructors to improve their syllabi so that it demonstrates a more learning-centered approach. For instance, instructors should clearly communicate their support for students' learning, explain the value of assessments and how they align with course objectives, and consider widening the range of course goals beyond the common "improve knowledge of chemical theory" and "perform of mathematical calculations".[16]

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Exploring Factors Within Chemistry Departments Which Shape Teaching Innovation

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Background Literature and Significance of Study

The growing disconnect between higher education outcomes and the competencies demanded by the science, technology, engineering, and mathematics (STEM) workforce has become an increasingly critical concern (NSF, 2020). Innovative teaching practices such as active learning can improve the persistence of students in STEM, contributing to the development of a competent workforce (Henderson et al., 2011). Despite this growing body of research, many instructors still depend on traditional teaching practices (Stains et al., 2018). This disconnect between what research recommends and what happens in many classrooms invites a closer look at the larger systems influencing instructors' decisions to engage with innovative reform. Further, faculty motivation to adopt evidence-based teaching can be shaped by the satisfaction of their psychological needs for competence, autonomy, and relatedness (CAR), as described in Self-Determination Theory (SDT; Deci et al., 2017; Ryan & Deci, 2022). Faculty members can perceive **competence** when they have a meaningful impact on their students, **autonomy** when they have freedom to teach lesson content their way, and **relatedness** when they have opportunities to connect and relate meaningfully with colleagues and students.

Even though SDT has been used to explore student motivation in different aspects of the chemistry discipline (Black & Deci, 2000) and faculty experiences in STEM fields (Crick et al., 2019; Seipel & Larson, 2016), there is very little research examining how chemistry departmental culture specifically shapes instructors' sense of competence, autonomy, and relatedness. This study responds to this gap by using the **four frames model** (Reinholz & Apkarian, 2018) to examine chemistry instructors' experience of their departmental culture. This model is made up of four interconnected frames: structures, symbols, people, and power. **Structures** focus on roles, responsibilities, practices, routines, and incentives that organize how people interact. **Symbols** refer to the informal cultural artifacts, language, knowledge, myths, values, and vision instructors use to guide their reasoning. **People** represent the unique and diverse experiences individuals in a department have with respect to their goals, agency, needs, and identities. Finally, **power** refers to how interactions between people are mediated by power, status, positioning, and political coalitions (Couch et al., 2024). The four frames and SDT help to understand the role departmental culture plays in influencing instructors' sense of competence, autonomy, and relatedness to foster an inclusive, collaborative, and supportive culture aimed at sustained pedagogical advancement.

We addressed the following research question: **How do chemistry faculty's experience of departmental culture (structures, symbols, people, and power) relate to their sense of competence, autonomy, and relatedness and their motivation to engage in teaching reforms**?

Methodology

To explore the relationship between departmental culture and instructors' sense of competence, autonomy, and relatedness, we collected data through a departmental culture survey

followed by a focus group interview with chemistry instructors at a public university in the southeastern United States. The survey was structured around competence, autonomy, and relatedness of departments in relation to teaching. During the interviews, members were asked to reflect on a previous survey response for each of the mentioned themes and review how their culture could explain the findings. Transcripts of the focus group interviews were coded qualitatively through deductive coding (using four frames; Reinholz & Apkarian, 2018). We leveraged the four-frames model definitions from Couch et al. (2024) to map faculty responses onto individual frames. Revisions were made to initial guiding definitions to incorporate more nuanced examples. We then coded within each frame using inductive coding strategies to identify emerging themes.

Summary of Findings

We provide emerging themes from the focus group interviews that show the way chemistry instructors experienced the culture and how these perceptions relate to their sense of competence, autonomy, and relatedness. Instructors mentioned several ways they perceived their experiences of ***structures***. For example, Marlene stated *"everybody in this room teaches stuff that other people teach. And Darlene, straight up, part of her job is to go collaborate with other faculty and graduate students to make sure her course functions correctly."* Hence, Darlene has opportunities to connect meaningfully with colleagues because of ***structures***, which influence her ***relatedness***.

For ***symbols***, instructors expressed difficulty in modifying their teaching practices. For instance, Heidi mentioned "*I think what I've noticed is that people who don't want to change seem to give messages like, I don't want to do the work to change my materials when what I have has been good enough for years*. *Because there is no real assessment for investigating teaching methods."* This shows the ***autonomy*** instructors have in deciding on whether to modify their teaching practices or not within the chemistry departmental norms.

The diversity of ***people*** was highlighted through the variation in instructors' perceptions of their ability to support all students. Tashiana, an early career instructor described "*I'm just in my first year and I don't feel confident. I'd probably say I was more confident as a GTA in my ability to support all students versus as an instructor, it's like I can do what I want with instructions, and I don't know which thing is going to work for all students."* This reveals the challenge Tashiana faced in identifying the kind of teaching approach that worked best for students in her new role as an instructor. Tashiana's unique experience (***people***), which makes her question whether her instructions work for all students: influencing her ***competence***.

Lastly, hierarchical ***power*** dynamics between tenure-track and non-tenure-track faculty left some faculty feeling undervalued and less able to contribute meaningfully. For instance, Darlene described a previous conversation, *"This year, somebody was standing in my office, another faculty member, and the words came out of their mouth that two people on their committee were not tenured, and so they could control them and make them do things."* This reveals how ***power*** dynamics play out in relation to faculty positioning, limiting the satisfaction of ***relatedness and autonomy*** for non-tenure-track faculty when contributing to decision making processes.

These findings reveal that chemistry instructor's sense of competence, autonomy, and relatedness is deeply related to departmental culture across the four frames, influencing how they engage with innovative teaching reforms. Although these findings reflect the context of an institution, they offer insights into how other departments can foster an inclusive, collaborative,

and supportive culture. Thus, departments that nurture inclusive structures for collaboration, create informal cultural norms that value teaching innovation, support diverse instructors and their unique experiences, and address the inequities in power dynamics are well-positioned to sustain teaching reforms.

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Crossing Boundaries in STEM Classrooms: Faculty-Learning Assistant Partnerships as Sites of Instructional Transformation

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Abstract

Calls for reform in undergraduate STEM education emphasize the need for evidence-based teaching practices that support deeper learning and broaden participation (PCAST, 2012; Freeman et al., 2014). Yet, faculty often struggle to sustain student-centered practices due to structural barriers, limited professional development, and the challenges of renegotiating professional roles and identities (Henderson et al., 2011; Hora & Ferrare, 2013). A critical but underexplored dimension of reform is understanding how faculty themselves experience learning through their participation in collaborative teaching models (G ehrke & Kezar, 2017).

The Learning Assistant (LA) model provides a promising context for such inquiry. By embedding undergraduate peer facilitators into STEM classrooms, LAs support the facilitation of collaborative learning and create opportunities for faculty to reimagine instructional roles (Otero et al., 2010; Barrasso & Spilios, 2021). While research has demonstrated the model's impact on student engagement and achievement (Clements et al., 2025; Talbot et al., 2016), less is known about how partnerships with LAs shape faculty professional growth and identity development. Addressing this gap is essential for advancing sustainable instructional reform in STEM education (Austin, 2011; Fairweather, 2008).

This study applies Akkerman and Bakker's (2011) boundary crossing framework (BCT) to examine how faculty-LA collaborations function as sites for professional learning. BCT emphasizes how learning emerges when individuals navigate discontinuities across practices, mediated by mechanisms of identification, coordination, reflection, and transformation. This framework extends prior work on communities of practice (Wenger, 1998; Lave & Wenger, 1991) by providing a lens to analyze how faculty navigate role redefinition and instructional change in collaborative contexts.

A qualitative case study design (Merriam & Tisdell, 2016; Yin, 2018) guided this research. Seven STEM instructors from general chemistry, general biology, and remedial mathematics courses at a large research-intensive public university in the Southeastern United States participated in two semesters (Fall 2024-Spring 2025), supported by up to four undergraduate LAs per course. Data sources included monthly faculty reflection meetings, classroom video recordings, and semi structured interviews with LAs. Data were transcribed and analyzed using reflexive thematic analysis (Braun & Clarke, 2022). Deductive codes, informed by boundary crossing constructs, were applied first, followed by inductive coding to refine themes grounded in participant accounts. Coding was conducted collaboratively through consensus sessions to ensure trustworthiness (Campbell et al., 2013; Lincoln & Guba, 1985).

Findings demonstrate that faculty experienced learning through each boundary-crossing mechanism. Through **identification**, instructors renegotiated professional roles, moving from sole authority toward shared instructional responsibility. **Coordination** occurred as faculty and LAs co-developed routines, such as lesson co-planning and accountability systems, which scaffolded new teaching practices. **Reflection** emerged when LAs surfaced overlooked student perspectives, prompting faculty to reconsider pedagogical assumptions. Finally, **transformation** was evident in the creation of hybrid practices, such as co-facilitated group work and new approaches to classroom interaction, that reshaped classroom culture toward inclusivity. These mechanisms collectively highlight how collaborative partnerships serve as catalysts for faculty identity development and instructional change.

This study contributes to STEM education research by reframing the LA model as a site of faculty learning, not only student support. The application of boundary crossing theory provides a novel lens for understanding faculty professional development as an ongoing, situated process that emerges in the classroom. For practice, the findings suggest that faculty-LA partnerships can be intentionally leveraged as sustainable models of professional learning, offering a pathway for equity-focused and enduring STEM reform.

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Do Students See Their Effort Differently? Perceptions of Academic Effort Across Undergraduate Grade Levels

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Background Literature

Student success in Science Technology Engineering and Math (STEM) programs depends not only on cognitive ability but also on students' self-perceptions of effort and persistence. Prior work suggests that undergraduates often equate effort with time spent studying, while faculty emphasize quality, strategy, and performance outcomes (Credé & Phillips, 2011). Similar to challenges observed in STEM pedagogy, where fragmented and inconsistent approaches obscure conceptual clarity (Stapleton & Shavelson, 2024), these mismatched perspectives on effort may hinder student growth. This is particularly the case in student-centered pedagogy that anchors learning responsibility on student autonomy, motivation, and interest (Felder & Brent, 2016) in order to apply conceptual understanding of technical concepts to real-world problem-solving scenarios. To this end, Wijnia et al. (2024) explained that student motivation is a multifaceted construct that can influence a student's engagement with instructional methods, like student-centered learning, with the impact of problem-driven learning on motivation being generally positive in STEM domains. In addition, the American Association of Colleges and Universities (2013) underscores the role that high-impact practices (HIPs) play in the development of professional skills for undergraduate students, which also plays a role in the effectivity of student-centered learning facilitation.

Data Analysis Procedure

Building on calls for systematic, theory-driven approaches to student learning (Kuh et al., 2007; Schunk et al., 2014), this study investigates how undergraduate student perceptions of academic effort evolve developmentally across the undergraduate journey. Specifically, we leverage survey-based data from a larger research project and adopt a quantitative approach to offer preliminary descriptive statistics and a correlational analysis related to students' conceptualization of academic effort based on their year of study. The instrument used combined Likert-scale items with open-ended questions to capture both quantitative trends and qualitative insights. This mixed-methods design echoes prior research that integrates multiple data sources to examine developmental shifts in student learning (Røykenes et al., 2024; Vasquez & Perkins, 2024). The data were collected from a student-centered learning activity implemented in an undergraduate chemical engineering course during one semester that centered on students' understanding of applications of conservation principles to engineering processes. The following are the research questions that guide this preliminary study.

Research Questions

1. How do undergraduate students at different grade levels perceive their effort in their academic work?

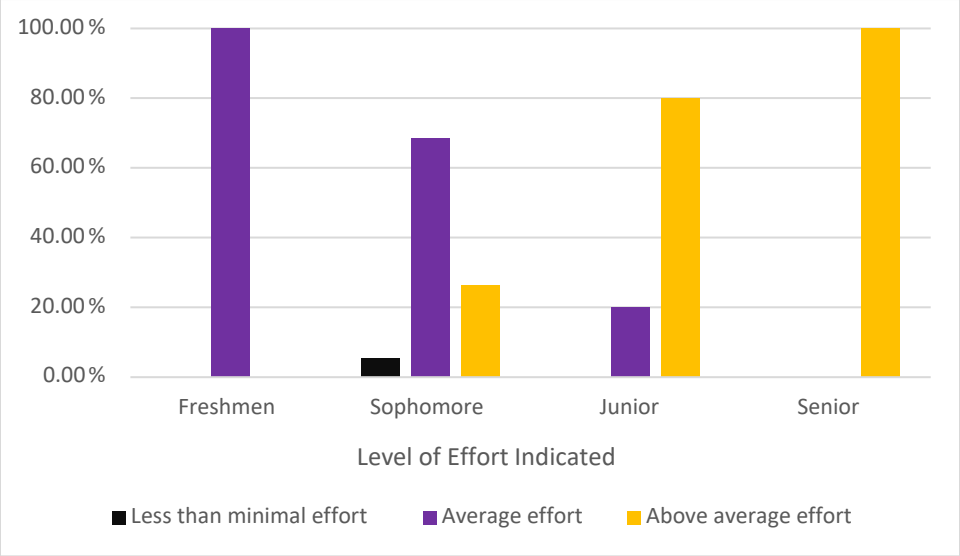
2. Does a relationship exist between undergraduate students' perception of effort and grade level standing, from freshman to senior year?

Summary of Findings

Figure 1 illustrates the distribution of this preliminary perceived level of effort descriptive statistics by grade level. Preliminary descriptive statistics from this initial pilot study indicate that freshmen and sophomores, in general, perceive that they put in average or less than average effort while juniors and seniors put in above average effort. These findings suggest that perceptions of effort may shift developmentally across grade levels. In the next phase of this analysis, a correlational study will determine if a relationship exists between perceived effort and grade level within this sample population, providing an indicator of motivation and effort in student-centered course engagement.

Figure 1.

Preliminary Analysis of Effort by Grade Level (n = 27)



Significance

By framing effort perceptions within a developmental and systematic perspective, this study contributes to a deeper understanding of student growth in STEM education. Findings highlight opportunities for faculty to calibrate expectations and feedback by grade level, incorporate metacognitive activities to emphasize the quality—not just quantity—of effort (Schunk, et al, 2014; Soderstrom & Bjorklund, 2023), and potentially strengthen advising and mentorship

practices that acknowledge changing student perception of effort (Kuh et al., 2007; Yang et al., 2024). Such evidence-based strategies can improve the alignment of instructional design with student experiences, ultimately promoting persistence, satisfaction, and success in STEM majors.

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Assessing Scientific Interest Before School Entry: A Multi-Method Approach

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Background & Significance.
Prior research shows that scientific interest supports learning outcomes in school-aged children (e.g., Bybee & McCrae, 2011; Mao et al., 2021; Potvin et al., 2020), yet its developmental trajectory in preschool and contributions to science literacy remain poorly understood. Better characterizing the factors that shape early interests in science has the potential to facilitate the development of interventions to address early emerging disparities in scientific literacy (Curran & Kellogg, 2016; Morgan et al., 2016). Progress in doing so, however, has been hampered, at least in part, by the lack of reliable and valid measures. This study addresses this limitation by evaluating the psychometric properties of several potential measures of preschoolers' scientific interest, adapted from other domains (e.g., early math interest) and from instruments originally developed for slightly older children.

Research Question. (1) Which measures demonstrate acceptable reliability? (2) Which measures demonstrate acceptable validity?

Methods. Forty-seven preschoolers (23 girls; *M*age = 4.83 years, *SD* = 0.55) completed four tasks: Free-Play Observation (FPO), Toy Interest Interview (TII), Science Activity Preference (SAP), and Science Interest Interview (SII). In the FPO, children played for 10 minutes with eight toys (four science-related, four non-science). The proportion of time spent with science toys served as the outcome. In the TII, children rated enjoyment of each toy using a pictorial scale (0 = did not like at all, 3 = liked a lot). In the SAP, children ranked their preference among three illustrated activities (one science, two non-science) across eight trials. Rankings were scored 2 points if science was most preferred and 0 if least. The SII consisted of six items in which children selected statements reflecting their general enjoyment in science using the same pictorial scale used for TII. Caregivers completed parallel versions of the TII and SAP, reporting how much they believed their child would enjoy each toy or activity. They also completed Likert-type questionnaires rating their child's interest in a range of science topics (12 items) and concepts (7 items) on a 4-point scale (0 = not like at all, 3 = like a lot). Together, these measures provided a multi-faceted approach to assessing scientific interest.

Data Analysis. Analyses first examined reliability. Internal consistency was acceptable for SII ($\alpha = .73$) and caregiver survey on scientific concepts ($\alpha = .70$), but not for TII ($\alpha = .59$), SAP ($\alpha = .42$), or the caregiver scientific topics survey ($\alpha = .61$). These lower reliability scores are likely due to the heterogeneity of sub-domains covered in those measures (e.g., interest in biology might not correspond to interest in physics). Validity was then assessed with zero-order correlations. None of the child measures significantly correlated with one another, but parallel child and caregiver reports showed significant convergence: TII ($r = .34$, $p < .05$) and SAP ($r = .42$, $p < .01$). These findings indicate that while children's responses are not always consistent across different measures, convergence validity is strongest between child and caregiver when tasks provide clear, concrete examples in both absolute (TII) and relative (SAP) forms.

Summary of Findings. Overall, the results suggest that no single measure provides a complete picture of early scientific interest. Questionnaires with good internal consistency (e.g., SII, caregiver concept survey) might be useful for capturing young children's general interest, whereas parallel child–caregiver tasks such as TII and SAP appear most reliable for assessing domain- and activity-specific preferences. Taken together, the evidence highlights the value of using both child self-reports and caregiver reports, when possible, while also indicating that a single informant can provide reliable information in contexts where resources or time are limited. Such a measure has the potential to provide a foundation for developing early interventions aimed at fostering scientific interest in young children.

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One Lesson on Science Communication Can Improve Undergraduate Biology Students' Communication About Culturally Controversial Science Topics (CCSTs)

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Background

Effective science communication is important for fostering public engagement and trust in science (Fischhoff, 2013), however, ineffective science communication can erode that trust in science and further polarize opinions about culturally controversial science topics (CCSTs) such as vaccines, evolution, and climate change (Hart & Nisbet, 2012). Research shows that undergraduate biology students are already communicating about these potentially polarizing topics but feel unprepared to do so and may be using ineffective communication tactics when they do (Bowen et al., 2023, 2025; Couch et al., 2022). Despite their desire to communicate effectively about these topics and for training on how to do so, opportunities for these students remain limited. The Theory of Planned Behavior suggests that students who have higher science communication self-efficacy will be more likely to engage in effective science communication (Murphy & Kelp, 2023), so students who have trainings in how to communicate about CCSTs may be more willing to have contentious conversations in ways that are effective for reducing conflict. However, it is likely that most undergraduate science students never receive formal instruction on how to communicate effectively about CCSTs, which may negatively impact not only their communication ability, but also their willingness to engage in conversations. What science communication trainings do exist are often extracurricular in nature and even students who value these skills may view the time needed to seek out training as too high of a cost (Cline et al., 2022). In order to better support these students' abilities to communicate effectively about CCSTs in a way that minimizes the perceived costs of this training, we need science communication training embedded into disciplinary classes. Thus, we developed a short science communication lesson implemented in an introductory biology course and studied its impact on students' perceptions of science communication about CCSTs as well as its impact on students' actual communication.

Research Questions:

1. How does science communication instruction impact the ineffective and effective science communication strategies that students use?
2. How does science communication instruction affect student confidence about their science communication abilities?
3. How do the identities and beliefs of students and their communities impact their communication experiences and perceptions?
4. How did instruction impact the way students value science communication?

Research Design: In this short module, students learned about effective and ineffective science communication tactics including their potential to serve as boundary spanners in their home communities, and the importance of establishing cultural competence when there are cultural differences. They practiced in class using worksheets where they explained how they would communicate with someone who did not accept climate change both pre- and post-instruction. We then asked them to transfer their knowledge of effective communication about another CCST and respond to someone with vaccine hesitancy. We analyzed these worksheets and interviewed these students 2-5 months after instruction to explore the impacts that this instruction had on students' science communication experiences and perceptions.

Analyses and Interpretations: Deductive coding of student worksheets showed that before instruction students overemphasized transmission of facts, underemphasized relational approaches, and presented their views in an argumentative manner when describing how they would communicate about climate change. After instruction, students reduced their use of ineffective tactics about climate change and increased their use of effective ones such as understanding the other person's point of view, asking questions, and finding shared values. Further, students continued to use more effective tactics in their vaccine communication. Inductive thematic analysis of student interviews 2-5 months later suggested that the instruction shifted students' actual science communication behaviors. Before instruction, students described using a deficit approach but after instruction described using more dialogue and relational approaches. Additionally, students described how they valued science communication skills for their utility both in their current classes and in their future careers. Finally, while students discussed how instruction positively impacted their confidence and willingness to communicate about CCSTs, they also described feeling as if they need more content knowledge and more practice with their skills to become effective science communicators.

Contribution: These findings suggest that inclusion of a single science communication module in an introductory undergraduate biology course can increase students' value of science communication, their self-efficacy doing science communication, and their use of effective science communication tactics. This may lead to an increase in students' willingness to engage in discussions about CCSTs and their ability to do so effectively, which could foster better public engagement and relationships between science and society.

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Cross-Cultural Mentorship and Academic Success: Pathways of Science Graduate Students

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Overview of Background Literature

Science graduate students from underrepresented racial groups (URGs) have been documented as having disproportionately negative academic and training experiences (Martin et al., 2019). Given the common goal of Science, Technology, Engineering, and Mathematics (STEM) graduate programs is to cultivate a culturally diverse and competent environment where all students thrive in becoming STEM professionals (National Academics of Sciences, 2018), it is imperative to critically examine the culture (norms, practice, values) and climate (department, program, field) of STEM graduate programs. Central to achieving this goal is improving mentorship dynamics.

Mentorship plays a pivotal role in student success, particularly for URG students (Byars-Winston & Dahlberg, 2019). Given the limited opportunities for URGs to have mentors who share their identities, many students enter cross-cultural mentorship dynamics where the mentor and mentee do not share the same identity makers (e.g. racial and gender identity) (Merriweather et al., 2022). Traditional mentorship models frequently fall short in addressing the unique needs of students from diverse cultural, racial and socioeconomic backgrounds (McCoy et al., 2015). However, mentorship models that can affirm cultural identities provide students with tools to leverage their unique strengths. This highlights the critical need for equity-minded mentorship practices in graduate education, particularly in STEM, where underrepresentation of URGs persists (Tuma & Dolan, 2024).

Few studies have focused on taking an asset-based perspective instead of a deficit-based perspective to examine the characteristics students bring into their research labs and programs (Yosso, 2005; Martin et al., 2019). Our study aims to highlight positive identity affirming mentorship practices and help graduate students leverage their unique strengths. Specifically, we focus on graduate students' perceptions of academic culture and climate, particularly within cross-cultural mentorship dynamics by using a novel asset-mapping activity (Kretzman & McNight, 1993), that enables students to gain a greater awareness of their contributions, resilience, and potential impact in the science field.

Significance of Research

Despite the existence of a body of literature focused on documenting the experiences of URGs (Ong et al., 2018; Stockard et al., 2021), much of the literature examines students primarily through one or two dimensions of identity (e.g. race or gender).

Such a narrow focus can overlook the complex dynamics students navigate, particularly in cross-cultural mentorship relationships. This project addresses that gap by examining how graduate students experience the culture and climate of academic science within these mentorship dynamics considering their diverse backgrounds. In doing so, we highlight the cultural assets students bring to academic spaces and show how those assets can challenge exclusionary norms they face while navigating competing identities and resisting norms that may marginalize them (Carlone & Johnson, 2007).

Research Questions, Data Analysis, and Summary of Findings

While prior research has examined mentorship dynamics, few studies have explored how positive cross-cultural mentorship shapes graduate students' experiences. To address this gap, we ask:

1. How do graduate students experience and navigate cross-cultural mentorship dynamics in science?
2. How do graduate students leverage their cultural assets to navigate the culture and climate of science graduate programs?

We conducted eight focus groups (N = 27) across six R1 institutions. Participants completed an asset mapping activity to document their self-identified strengths and contributions to their research labs and graduate programs. The focus groups provided a platform for participants to share their lived experiences and engage in rich discussions about academic science culture. Guided by frameworks of community cultural wealth, science identity, and intersectionality, we analyzed how graduate students experience their research labs, graduate programs, and the broader field (Yosso, 2005; Carlone & Johnson, 2007; Avraamidou, 2020; Crenshaw, 1989).

Preliminary findings indicate graduate students draw on diverse forms of capital and assets to persist and thrive in graduate education. (RQ1) Students navigate academic systems by applying adaptive strategies, inherited power skills and resilience rooted in cultural and familial values, including a belief in persistence and hard work. (RQ2) Long standing support networks and collectivist values foster collaboration, mutual uplift and the creation of culturally affirming spaces that challenge individualists STEM norms. Our findings aim to inform mentoring practices and graduate program policies by highlighting how cultural assets can be leveraged to enhance inclusion, persistence, and success for all students in STEM.

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How A Science Communication Research Course May Affect Student Science Identity and Belonging

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Background and Framework

Effective science communication (sci-comm) to the general public is a desired skill of biology graduates[1,2]. It is critical in gaining public trust in science, especially around culturally controversial science topics (CCSTs) like climate change, vaccines, and evolution.[3] Participating in research or sci-comm can increase students' science identity[4,5], promote retention in science majors[6], and increase their desire to pursue science careers.[6] In this study, we explored how a sci-comm research course may impact students' science identity.

Current literature suggests that science identity may be affected by three interconnected parts: the students' ability to demonstrate their competence (competence-performance), self-recognition and the recognition by others as a science person (recognition), and interest in science.[7] Furthermore, Carlone and Johnson (2007) found evidence for three types of science identities: a research science identity, which is characterized by an innate interest in discovering knowledge through science; an altruistic science identity which is characterized by a motivation to help others through science; and a disrupted science identity in which self-recognition as a science person is not corroborated by others.[8]

Significance of the study

We developed a science communication research course that allows students to perform research on how undergraduate biology students communicate CCSTs, while at the same time being trained in science communication. Unlike traditional sci-comm (e.g., community engagement and outreach), this course emphasized how to engage in productive interpersonal dialogue. Using a case study approach, we compared the course experiences of two students with different science identities, whom we call Tyr and Grace, who were partnered to discuss their differing views on human evolution during the course. Our research questions are as follows: RQ1) What role, if any, did the science identities of Tyr and Grace play in motivating them to take a sci-comm research course?; RQ2) In what ways, if at all, did the sci-comm research course support the science identity development of Tyr and Grace in terms of competence-performance, recognition, and interest?; and RQ3) How, if at all, did the sci-comm research course develop Tyr and Grace's skills for communicating across differences about science, and what did they still feel like they needed to develop further after the course?

Data analysis procedure

Multiple data sources were used in the analysis: transcribed pre-/post-course interviews, written homework, three transcribed conversations between Tyr and Grace about human evolution, and student reflections on each conversation. The documents were coded inductively to understand student motivation and perceptions about the course, then deductively coded for science identity

according to the current science identity framework[7], and for evidence of their development as effective communicators. Two authors met to verify data interpretation.

Summary of findings

Tyr, who held a research identity, enrolled in the course for more research experience. He believed it would help him communicate science better, which he values for a research career. Grace held no science identity at the start of the course but was interested in our course for the perceived benefits to her desired career in environmental remediation. She admired popular science communicators' ability to impact others through their passion for science. This would contribute to an altruistic science identity, which she developed over the course of the semester.

The research component of the course allowed Tyr and Grace to develop competencies in qualitative research. Tyr found the data analysis part of the course rewarding for its relevance to his bench research on bacterial symbiosis. Grace found collaborating with other students beneficial. These results align with their different research and altruistic science identities.

The conversations about human evolution let students demonstrate their science communication competencies, and the subsequent reflections provided opportunities for self-recognition and peer-recognition. Tyr said the discussions helped him feel more confident in communicating science, which will be valuable when he shares his research. He reported that this increased his science identity. Grace also noted that the conversations helped her feel more confident in communicating. She attributes the entire course to recognizing how science communication could help her impact others positively. This insight led her to shift her career goals from environmental remediation to environmental policy and outreach, aligning her interest in environmental science with her desire to help others. These results highlight how individuals with unique science identities can perceive different benefits from the same course instruction.

In their peer feedback, Tyr and Grace recognized each other's use of effective communication skills like showing goodwill[9], being open-minded[10], and demonstrating intellectual humility in their conversations.[10] This created space for Grace to change her views and accept the geological age of the Earth. Both Grace and Tyr consider science people to be effective communicators, so the positive peer recognition they received from each other likely increased their perception of themselves as science people. Grace reported that realizing science communicators don't need to know everything to impact others positively helped her see herself as a science person. Tyr and Grace felt that more practice discussions with other people would increase their confidence in communicating science.

Broader Impacts

Research has shown that participating in traditional sci-comm, like community outreach, can support science identity development.[5] Our results suggest that participating in interpersonal science communication may have similar effects. To build trust in science, it is important for

scientists to demonstrate competence when communicating. However, perceptions that scientists must be brilliant and "know everything" to succeed may prevent students from seeing themselves as a science person.[11] Promoting the idea that scientists have intellectual humility may be a way to combat this and increase student belonging in science. Finally, Tyr and Grace's respectful dialogue across ideological views on human evolution allowed Grace to change her perspective on the age of the Earth. This highlights the possible outcomes of using effective sci-comm techniques when communicating about CCSTs and the benefit of teaching and engaging college students in sci-comm.

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Impacts of the Morehouse TRIO STEM Pipeline Program on Student Outcomes: A Pre-Post Evaluation

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Introduction:
The Morehouse TRIO program is a federally funded program that supports historically under-resourced and under-prepared students in intensive STEM training, mentoring, and providing academic support. This study evaluates changes across six key domains of the summer program evaluation - STEM Identity, Career Awareness, STEM Intent Persistence, STEM Self-efficacy, STEM Motivation, and STEM Skills - comparing self-report responses before and after the program.

Methods:
Participants (n=124) completed validated Likert-scale surveys at program entry ("Before") and immediately before exit ("Now"). For each domain, composite scores were created from multiple items. Paired t-tests assessed statistically significant changes. Effect sizes were calculated to gauge practical impact.

Results:
Across all six domains, students demonstrated statistically significant gains ($p < 0.01$). There was an increase of more than 20 percentage points in the participants who strongly identified with STEM. Awareness of STEM skills and career options moved from majority-neutral to majority-agree/strongly-agree. Metrics of motivation and self-efficacy also moved in the direction of increased confidence: "strongly agree" answers increased from about 20–25% to about 35–45%. Similarly strong gains were seen in STEM skills.

Conclusion:
This assessment demonstrates that students' STEM identity, confidence, motivation, and skills significantly improved as a result of their participation in the Morehouse TRIO program. To maintain gains, future research should look at long-term effects and improve curriculum elements.

The Effectiveness of the Climate Literacy in Undergraduate Education Active-Learning Intervention to Increase Climate and Climate Change Knowledge and Perceptions Among University and Community College General Education Students

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Background

As global temperatures continue to rise, the southeastern United States is forecasted to experience longer warm seasons, with more frequent, longer lasting, and more intense thermal events [1–4]. Exposure to these extreme thermal conditions is a public health issue to all populations, especially those in urban areas where the urban heat island exacerbates extreme heat and increases heat exposure and heat health-related morbidity and mortality [5–10]. Traditional ambient weather is measured through fixed-location hourly weather stations, such as those at airports. However, these data do not capture the variability of heat exposure within microclimates of urban areas and do not identify more vulnerable populations that need increased resources and mitigation during thermal events [11–15]. To better understand heat exposure on the individual level, researchers use cutting-edge wearable sensor technology (e.g., iButtons, Kestrel Drops) to analyze individual heat exposure in communities [14–17]. Studies have shown increased heat exposure during the normal warm season, at night, and among vulnerable urban populations [14, 17, 18].

Building on the ideas of microclimates and heat exposure, the larger discussion of global climate change (GCC) can be tied directly to the local environment. Undergraduates, especially those residing in or attending school in urban areas, often have very different day-to-day habits than the general community as they populate and move about campus, may live in dorms or less insulated housing, and often hold part-time jobs [19]. While studies have shown that students in the southeastern United States have low climate and heat risk perceptions and are generally apathetic to thermal events, they report experiencing mental (e.g., anxiety, agitation) and physical (e.g., fatigue, dehydration) health effects during heat waves [20]. Heat perception affects heat exposure, with those experiencing previous heat related illnesses, having co-morbidities, and lower income often reporting a higher heat risk perception [19].

In a survey conducted by the Yale Program on Climate Change Communication, 72% of individuals in the United States stated that global warming was occurring, but only 57% indicated that it was primarily influenced by humans [21]. This result contrasts with the overwhelming consensus within the science community about human-caused global warming [22]. The lack of consensus outside of the science community may exist because debates around GCC are often times politically-driven, rather than scientifically-driven, which can attribute to individuals' understanding of the nature of the science [23– 26]. Teaching GCC is an integral part of earth science education [27]. However, the way it is taught can vary between teachers because of the political nature surrounding it [28]. Therefore, development of interventions that

explicitly target the scientific and social concepts related to GCC while also providing training to instructors is needed to help encourage consistency across the discussion of GCC. Increasing knowledge of GCC and microclimates, as well as increasing risk perception through project-based activities in college classes can help students better understand these topics on a personal level.

Significance

Although there are several climate curricula in use [29–32] and field geology courses, workshops, and fieldtrips have grown in their use of technology, participants are often limited to STEM majors or do not tie directly to the individual level. A unique combination of active learning and using exciting new technology has the potential to positively impact both comprehension of climate, GCC, and microclimate topics and align attitudes of climate change closer to scientific consensus. GCC can be a challenging subject to approach in classrooms with a diversity of educational backgrounds and climate is difficult to observe on a short-term basis. Bringing GCC to the personal level for students can help them identify key concepts and form a stronger connection to the science. Students directly benefit from collecting their own data that they can then visualize, interpret, and use to form their own understanding of what they personally need to do to protect themselves and those around them from the dangers of changing climate and urban heat. Increasing their knowledge on these topics and participating in relevant and interactive research involving themselves can potentially decrease climate anxiety, which is common among younger populations [33].

To the benefit of science education, this intervention also offers instructors training in the implementation of GCC project-based learning practices to help develop instructors' knowledge of the current GCC science and increase confidence in teaching GCC, which we hope will encourage the continued use of project-based learning in future iterations of this intervention. The adaptable curriculum that results from this project and option to borrow equipment increases the capacity of instructors from anywhere in the U.S. to implement this project. This, then, increases the number of students reached, especially in schools where resources are limited.

The Study

Main research question: How does interventions including climate change active learning curriculum and involve using urban microclimates as an environmental laboratory affect general education students' understanding and perception of global climate change.

The Climate Literacy in Undergraduate Education (CLUE) program includes six newly developed short lectures, assessments, and lecture activities that address earth's energy, earth's spheres and climate, microclimates, the basics of climate change, human alterations to climate, and the effects of climate change. Instructors implement the program into their general education geoscience classes by using provided PowerPoints or recorded lectures and associated curriculum and assessments. Students then spend two days collecting their own personal environmental exposure (temperature and heat index) data using wearable hygrochron ibuttons sensors [34]. Students are provided with their data and the anonymous data of their classmates.

They walk through data analysis using Excel to better understand their exposure, how their exposure compares to other sociodemographic subsets of the class (e.g., housing type, working outdoors vs indoors), and how these data are related to GCC. Students complete mixed qualitative and quantitative pre- and post-program surveys to track their knowledge development and perceptions throughout the program. Students additionally complete a one-month post-program knowledge retention survey to indicate their retention of the intervention materials.

The curriculum was implemented in eight Middle Tennessee State University (MTSU; $n = 1089$) and two Pasadena City College (PCC; $n = 56$) general education geoscience classes and results reflect the intervention's effectiveness. The curriculum is being further tested at four community colleges ($n \approx 170$) in October 2025. Key knowledge indicator questions on all surveys were analyzed using ANOVA, Tukey HSD ad hoc tests, and regressions and indicate that significant ($p < 0.001$) climate and GCC knowledge gain occurred during the curriculum at both institutions. There is stronger evidence of knowledge gain during the CLUE program at MTSU than at PCC; however, students at PCC started the program with more climate change knowledge than MTSU students, potentially reflecting local differences in K-12 education or sample size variations between the institutions. There was no significant difference between the post program survey and the one-month knowledge retention survey, indicating that the curriculum was effective at helping students retain the climate change knowledge they gained during the program.

The CLUE program additionally helps to align students' perception of climate change with scientific consensus, with stronger evidence recorded at PCC than at MTSU. Specifically, there were significant increases in perceptions that current global warming is caused by humans, personal confidence that global warming is occurring, and that most scientists agree that global warming is occurring.

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Project BECAUSE: Building Educator Capacity for Authentic and United STEM Education (BECAUSE)

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1. Overview and Rationale

The purpose of this co-design project will be to **elevate unique contributions of teachers and community partners** in the development of **STEM professional learning for teachers** that connects formal and informal education from local contexts. This project will serve as the inception of a partnership involving leaders in classrooms, communities, and higher education. Specifically, a collaborative team will identify opportunities to align school-based STEM curriculum and teacher learning experiences provided at Lone Oaks Farm (LOF), the research partner in this community-engaged project. The team will develop teacher professional learning, hosted by LOF, to support **authentic STEM learning** in the Mid-south region.

1.1 *Significance of this Research*

Data will be collected to understand what aspects of the co-design process support or impede teacher agency. Results of this study will support future professional learning development strategies that build **educator capacity for agentic change**. This participatory co-design project is important because:

1.1.1 Effective teacher professional learning supports authentic STEM Education. Effective professional learning PL helps teachers design inquiry-based, problem-centered lessons that situate STEM in authentic community, environmental, and societal challenges (Penuel et al., 2007). Well prepared teachers can integrate students' cultural knowledge and lived experiences into STEM instruction, making learning meaningful and representative (Tan et al., 2019). More **research is needed on models that meaningfully involve teachers in the planning, designing, and evaluation of PL for STEM education**.

1.1.2 Teacher agency influences school improvement. Agency is increasingly recognized as central not only to school improvement but also to practitioner emancipation and professional identity development (Durrant, 2021). Teachers who are valued as trusted collaborators develop their capacity as agentic leaders (Caudle et al., 2014). Participatory co-design enhances teacher agency, which is strongly linked to sustained growth and improvement (Butler et al., 2015). Yet, further **research is needed to understand how partnerships as professional learning can support teachers' development** (Thompson et al., 2015).

1.1.3 Involving teachers in the co-design of professional learning builds agency. Participatory co-design is a collaborative design approach that brings together researchers, practitioners, and community stakeholders to create solutions through shared decision-making, expertise, and responsibility (Sanders & Stappers, 2008). Participatory co-design emphasizes active engagement, mutual learning, and empowerment, ensuring outcomes are contextually relevant and grounded in local knowledge (DiSalvo et al., 2013; Penuel et al., 2007).

More empirical studies are needed to understand **how co-design with teachers and community partners influences agency in STEM learning** across different educational contexts (Günal Aggül & Öner, 2023).

2. Conceptual Framework

This study utilizes a socio-ecological model of agency developed by this author that incorporates **temporal** (Emirbayer & Mische, 1998), **relational** (Eteläpelto et al., 2013; Penuel et al., 2011), and **structural** constructs (Biesta, et al., 2015). The dimension of time is especially applicable as we evaluate change in agency. Findings will contribute to insight into this research question:

What aspects of participatory co-design of teacher professional learning support or impede agentic change in teachers and community partners?

Answering this question is critical for developing **equitable and sustainable PL models** that recognize the expertise and contributions of both educators and community collaborators.

3. Research Design and Methods

In **November 2025**, teachers from diverse contexts will begin the **participatory co-design process** with LOF to develop STEM PL opportunities for teachers. During a series of approximately 6 development meetings, team members will utilize local and regional resources to create PL that connects their classroom curricula and LOF STEM curriculum. Meetings will be held in-person and through videoconferencing. The PL is anticipated to launch in **Spring/Summer 2026**, based on the decisions of the PL development team.

3.1 Data Collection and Analysis

Data generation will include **video and audio recordings** of meetings, **audio diaries**, researcher **field notes** and semi-structured **interviews**. Each of these will provide rich insight into the experiences and perceptions of the educators. The qualitative data will be analyzed for changes in the individual as well as comparing across participants using deductive thematic coding. Audio diaries are particularly useful for capturing teachers' evolving sense of agency — how their decisions, confidence, and relationships shift across time and contexts (Eteläpelto et al., 2013; Priestley et al., 2015).

4. Significance and Expected Outcomes

As the meetings will begin in November 2025, preliminary findings are expected by the 2026 Southeastern STEM Education Research Conference in January. This project will generate new knowledge about how participatory co-design impacts agency among both teachers and community partners. It is expected to contribute to a deeper understanding of the mechanisms through which co-design fosters professional agency, as well as to the development of equitable professional learning models that draw on local expertise and community collaboration.

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Examining How Departmental Norms and Mentorship Shape First-Generation Chemistry Students' Motivation, Science Identity, and STEM Persistence

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Brief overview of background literature.
First-generation (FG) college students enter STEM with distinctive cultural assets yet face structural and cultural barriers to belonging and persistence in STEM disciplines (Marco et al., 2024). The chemistry teaching culture is often framed by speed, objectivity, and individual performance (King, 2012). Students may read subtle signals about who matters due to this culture, which can exacerbate identity incongruence and imposter feelings (Robinson et al., 2019). Two sociocultural lenses motivate this work. Community Cultural Wealth (CCW) reframes FG college students from "deficit" (i.e., lacking skills) to asset by foregrounding aspirational, navigational, resistant, familial, social, and linguistic forms of capital that FG students already possess (Yosso, 2005). Boundary Crossing Theory (BCT) conceptualizes how learners negotiate identities and practices at the interfaces of home, department, and mentoring communities (Akkerman & Bakker, 2011). Literature on mentoring (Atkins et al., 2020; Moon et al., 2025) and messaging (Canning et al., 2024) further suggest culturally responsive mentorship and growth-mindset/utility-value messages can reposition students' identities and improve outcomes, yet few studies integrate these strands in chemistry specifically.

Significance of the research.
This study addresses an underexplored intersection: how chemistry departmental norms and mentoring jointly influence FG college students' motivation, science identity, and persistence. By pairing CCW with BCT, we illuminate both the cultural assets students mobilize and the boundary processes through which they navigate chemistry's local norms. This work aims to produce actionable implications for mentoring design, departmental policy, and instructor messaging that are sensitive to chemistry's disciplinary culture. This study considers the FG college students in undergraduate chemistry perception of departmental norms, through mentoring relationships affirming or conflicting community cultural wealth, which shape the students' science identity. We sought to explore this through the overarching question: *How do the FG college students in undergraduate chemistry perceive departmental culture, and in what ways does mentoring support or thwart building positive perception*?

Design and Analysis.
This study is part of a larger study and uses data from FG college students in a chemistry department. We conducted semi-structured, one-on-one interviews with first-generation undergraduates in chemistry. Interviews (~45–60 min; in person) probed belonging/culture, mentoring, workload/navigation, and views of error/learning. Example prompts: "To what extent have your mentor(s) supported you in achieving your academic goals?" "On a scale of 1-5, to

what extent do you feel part of the science community? Can you explain why you feel that way? "Can you tell me if you feel similar to your peers who are pursuing a science degree? Sessions were audio-recorded with consent, transcribed verbatim (auto-draft + manual check), deidentified (pseudonyms; scrubbed identifiers), and line-numbered. Using a hybrid thematic analysis (Braun & Clarke, 2006), we applied a priori codes from CCW (navigational, resistant, familial capital) and BCT (brokerage, identity repositioning, boundary objects), added inductive codes for emergent meanings, refined the codebook on a subset (dual-coded → reconciled), then coded the remainder with memoing and an audit trail. Themes were developed and verified against data with exemplar quotes..

Summary of findings.

Students characterized the departmental culture as exclusive, and this experience was shaped by intersectionality, positioning them at the margins of the scientific community and dampening belonging and motivation. As one student noted, "my last two labs have… shifted my perspective… they have given less and less guidance… to have you figure it out… being at that point makes you… [realize] you do know this, you can do it." The same cultural signals that marked who "counts" in science also narrowed students' sense of legitimate participation: "there are people who have been here longer than I have been alive… there is so much to learn… I feel like I am at the very tip of the iceberg… before I can feel fully part of the science community."

At the same time, students reported learning that mistakes are a natural and necessary part of scientific development, reframing error as integral to inquiry rather than a deficiency. One student reflected, "hearing her confide that she made a C- minus in physics… I did not know you could mess up… it was okay for me to hit a bump… I do not have to make straight A's to stand a chance for medical school."

Students also drew on familial capital to navigate institutional processes and persist, with family guidance functioning as a practical and motivational resource: "my mom… no matter if I failed or got an A… told me I am still successful… I should not give up." Mentoring further supported academic achievement and identity development by translating tacit expectations and clarifying authentic practice: "I was mentored to do a poster presentation… I did not think I would win… and then I won." Mentoring also had blind spots, however, especially limited awareness of students' workload, which contributed to stress and risk of burnout: "when you assign me so much, I can only do so much… it's an awkward predicament to tell your advisor, 'I'm overwhelmed."

Discussion

The results suggest that belonging for first-generation students hinges on aligning departmental signals with everyday practices. Through CCW, students' use of familial guidance is not incidental but an asset that sustains helpful navigation; this is not a substitute for institutional responsibility (Yosso, 2005). Through BCT, effective mentoring looks like brokerage: translating hidden rules so students can reposition themselves as legitimate participants; without attention to

workload, the same relationships can inadvertently amplify strain (Akkerman & Bakker, 2011). The view that mistakes are integral to inquiry implies pedagogy should operationalize iteration (e.g., revision credit, brief error-debriefs) so messages about "learning from mistakes" are experienced, not merely stated (Allchin, 2012). Practically, pairing workload-aware mentoring check-ins with small, structured brokerage (poster norms, authorship, email scripts) is a plausible, low-lift change that the mentor-training literature indicates can improve mentee fit and clarity (Byars-Winston et al., 2023).

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Chemistry + Libraries → Better Learning

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The American Chemical Society (ACS) guidelines for chemical literacy, in undergraduate programs, are in three critical areas: information retrieval, information evaluation, and information management. As part of an ACS certified degree (1) students receive instruction in effective methods for performing and assessing the quality of searches using keywords, authors, abstracts, citations, patents, and structures/substructures; (2) students can use chemical identifiers to locate physical and chemical properties in handbooks and databases; and (3) students are assessed in their ability to conduct effective searches by reading, analyzing, interpreting, and citing the chemical literature as applied to answering chemical questions.[1] There is an assumption that first year graduate students have learned these chemical literacy skills as part of their undergraduate degree. However, despite this ACS certification requirement, many students have had minimal engagement in the three critical areas from faculty and staff.

STEM students, faculty, and staff are often unaware of information literacy resources and pedagogical support available to them. Perhaps more importantly, even when they are aware of academic support, many STEM students feel like they are (silently) discouraged from seeking help from these resources. The perceived bias is, I should be able to figure things out myself, otherwise how can I expect to be considered a *real* scientist? This phenomenon is exacerbated by imposter syndrome and only worsens as chemists climb through the academic ranks. For example, new faculty are often given instructional responsibilities without prior training or significant support for their new academic responsibilities. In this presentation, we aim to highlight ways in which we can normalize the librarian as a partner in academic and research endeavors for undergraduate, graduate students (particularly TAs), staff, and faculty.

There is precedence for welcoming subject specialist librarians into chemistry classrooms and teaching laboratories. The literature contains information about an honors general chemistry exercise very similar to the one employed in honors general chemistry lab (CH 126) at UAB – a subject specialist librarian is brought in to introduce the use of proper syntax for searching the scholarly literature, which empowers students to create their own lab experiments within the course.[2,3] Tomaszewski also makes a bold argument for embedding a librarian in laboratory courses. The librarians provide training on software and database usage to both the course's students and the faculty.[4] Furthermore, there is also precedent for including chemical information literacy instruction throughout the chemistry curriculum, such as the Stepping Stone Approach of Yeagley et al.[5] by integrating critical information literacy skills, over multiple years.

Teaching faculty and staff from the Department of Chemistry at the University of Alabama at Birmingham are embracing their relationship with the subject specialist librarian to support teaching, learning, and research endeavors for both undergraduate and graduate students.

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POSTER PRESENTATIONS

AUTHORS AND ABSTRACTS

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SOUTHEASTERN STEM EDUCATION RESEARCH CONFERENCE
Celebrating 20 years of STEM Education Research

2026

A Learning Sciences STEM Education Agenda for the Age of AI

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Introduction, Background, and Significance

Generative AI disrupts educational paradigms, presenting opportunities and challenges for STEM education [1]. AI applications often surpass human performance in knowledge processing and skill execution [2] yet occur within educational systems shaped by industrial paradigms prioritizing efficiency and standardization [3]. Contemporary educational structures emerged from Taylorist principles emphasizing standardization and task simplification [4]. This "factory model" treated education as manufacturing with predetermined inputs and outputs [5], evident in standardized curricula and efficiency-focused assessment [3].

STEM education faces a choice: intensify industrial approaches to compete with AI or recognize AI as opportunity to transcend these limitations [6]. Research suggests three AI-education paradigms [7], yet these operate within traditional frameworks focused on knowledge acquisition rather than human development. If AI systems handle routine information processing more efficiently than humans, emphasizing these capabilities in human education may be counterproductive [8]. STEM education must cultivate distinctly human capabilities complementing AI systems, requiring movement beyond industrial models. Educational systems can leverage AI to create space for human development, fostering creativity, wisdom, and meaning-making through authentic engagement [9]. The research question was: How can STEM education be reconceptualized to move beyond industrial paradigms and cultivate distinctly human capabilities that are enhanced rather than replaced by artificial intelligence?

Methods

This literature review synthesized research from AI in education [1,2], educational paradigm history [4,5], humanistic and constructivist theories [10,11,12], and situated learning theory [13,14], emphasizing empirically-supported approaches fostering deep learning and human development.

Findings

Literature reveals a convergent framework around three interconnected dimensions of human development that resist mechanization: ways of being, knowing, and doing. Through emphasis on these three dimensions AI is no longer artificial, but *augmented intelligence* (AI).

Ways of Being encompass the ontological dimension of human existence, questions of identity, purpose, values, and fundamental relationships to self, others, and world. This includes developing wisdom, ethical reasoning, emotional intelligence, and capacity for meaning-making through lived experience and reflection [11]. Research in humanistic education demonstrates that these capabilities emerge through relationship, mentorship, and sustained engagement with generative questions rather than through transmission or programming [12]. Humanistic learning

theory emphasizes the importance of seeing the "whole person" and supporting self-actualization through intrinsically motivated learning experiences [10]. These ways of being cannot be algorithmically replicated because they emerge from the irreducible complexity of human experience, cultural context, and interpersonal relationships that shape individual identity and purpose.

Ways of Knowing represent epistemological dimensions, not just what we know, but how we come to know, what counts as valid knowledge, and how we navigate uncertainty and ambiguity. This includes developing intuition, pattern recognition that transcends algorithmic processing, and capacity for creative synthesis that generates genuinely new understanding [14]. Constructivist learning theory supports this dimension, emphasizing that learners actively construct knowledge through interaction with authentic contexts rather than passively receiving information [14]. Research demonstrates that human ways of knowing are inherently contextual, embodied, and culturally situated in ways that resist standardization [15]. Unlike AI systems that process information through predetermined algorithms, human knowing involves tacit understanding, aesthetic judgment, and the ability to hold multiple perspectives simultaneously while navigating the tension between certainty and uncertainty.

Ways of Doing encompass methodological dimensions, not just technical skills, but capacity to engage authentically with complex, novel situations that require improvisation, collaboration, leadership, and graceful response to unexpected challenges [16]. Situated learning theory provides empirical support for this dimension, demonstrating that authentic learning occurs through legitimate peripheral participation in communities of practice where learners engage with real-world challenges [13,17]. Such learning environments foster adaptive expertise characterized by integration of multiple forms of intelligence and grounding in ethical and aesthetic considerations beyond mere efficiency [18]. Human ways of doing are distinguished by their integration of technical competence with moral imagination, aesthetic sensitivity, and the ability to respond to unprecedented situations with creativity and wisdom.

The power of this framework lies in recognizing the fundamental interdependence of these three dimensions. At their intersection lies the space of interdisciplinary and transdisciplinary integration where authentic human expertise emerges. This integrated space cannot be reduced to component parts or standardized procedures but emerges through sustained engagement with authentic challenges, mentorship within communities of practice, and deep reflective engagement [19]. The methodological rigor of ways of doing intersects with the wisdom of ways of being and the creativity of ways of knowing to generate responses to complex challenges that are both technically sophisticated and deeply human.

Conclusion

This review suggests AI creates opportunity for STEM education to move beyond industrial paradigms toward approaches cultivating distinctly human capabilities. STEM education can leverage AI to handle routine tasks, creating space for humans to engage with ways of being, knowing, and doing that resist mechanization. This framework aligns with the learning sciences [2023] in calling for STEM education environments supporting sustained engagement with authentic challenges, prioritizing depth over coverage. Such environments would be more

agentic, relational, and responsive to individual trajectories. This transformation requires moving beyond familiar paradigms, presenting opportunity to align educational practices with human flourishing in partnership with AI systems.

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Assessing the Fidelity of AI-generated Lessons for Elementary-grades STEM Topics

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Significance of the research

An artificial intelligence (AI) generator holds the potential to assist the teacher with lesson planning, including selection of content, lesson sequencing, and brief assessments. In this project, UTC pre-service teachers and area in-service teachers collaborated to use MagicSchool

(n.d.), an AI tool for generating lesson plans, to create lessons for elementary-grades mathematics, science, and technology topics. Upon completion of each set of lesson plans for each of the three content areas, the lessons were evaluated for fidelity to the content and lesson plan components.

Brief overview of the background literature

This project is consistent with ideas presented in the following, brief review of literature. Rooj and Kewalramani (2023) discussed benefits of AI tools in the classroom, suggesting AIgenerated content could be used as a tutor for struggling students. The teacher could use an AI tool to help develop lesson plans and materials for classes, allowing students to practice skills, providing the teacher with endless examples, and allowing the teacher to easily create group assignments and quizzes for students to solve together, promoting cooperation among students. Neebe (2023) addressed one main concern of teachers: AI might replace original thought in the classroom. The teacher should understand AI cannot replace original thought, which will always be present and different from artificially-generated thought. Spencer (2023) addressed similar concerns, with regard to higher education professionals, allaying fears that students and faculty will become too reliant on AI tools to have their own ideas. It is noted AI is becoming more common in our society and a way must be found to coexist with AI software. It would be better to work with the tools in balance than to ignore the benefits the tools can provide. Spangler (2023) discussed concerns of educators when considering how, when, and if to use AI, including the need to become more familiar with tools and the perception AI creates an unauthentic experience where the teacher does not interact with the student in the same way as currently done. With regard to student learning support, a tool is used to help digitally tutor students in various subjects by creating different learning tasks for the student. Murtaugh (2023) added that the teacher should sculpt how their class uses tools in a constructive way and encourage student usage of tools as it is the way of the future. Gaskell (2023) suggested different tips for the educator choosing to use AI in the classroom, including double-checking the information the program provides for errors and ensuring the prompts given to the system speak the AI tool's language well enough to generate appropriate responses.

Research questions, data analysis procedures, and summary of findings

One definition of fidelity is the degree to which a copy of something shows the true character of the original (Cambridge Dictionary, n.d.). The problem to be answered is two-fold: What is the fidelity of AI-generated lessons for elementary-grades STEM topics? What are teacher perceptions of using an AI tool? Using the MagicSchool AI tool, teachers participated in work sessions in which they generated and evaluated lesson plans on STEM topics for elementary grades. Three Saturday work sessions allowed for concentrated study, for 1 day each, of mathematics, science, and technology lessons. Standards-based topics and grade levels were entered by teachers and MagicSchool generated the lessons. Lessons were assessed against two rubrics: (a) selected indicators of the Tennessee Educator Acceleration Model (Tennessee Department of Education, 2022), used for teacher evaluation in most counties; and (b) selected indicators of the Project COACH Evaluation Model (developed and implemented by Hamilton County Schools, 2012). Scores for lesson plans were compared by content area (mathematics, science, technology) and by elementary level (lower versus upper) to determine if fidelity is better for a particular content area or level. Teacher perceptions, regarding the use of an AI tool, were surveyed through an instrument (Chounta et al., 2022), at the beginning and the end of the first session attended. Results showed significant differences in score for science lesson plans, with lower elementary grades lessons scored higher than upper elementary grades lessons, and for technology lesson plans, with upper elementary grades lessons scored higher than lower elementary grades lessons. There was no significant difference for scores of mathematics lesson plans, with regard to grade level. There were significant differences in score for lesson plans by content area, with science lessons scored higher than technology and mathematics lessons, and technology lessons scored higher than mathematics lessons. Qualitative results for the survey showed (a) an increase in participants' confidence in their understanding of AI; (b) participants learned more ways AI could aide them in their teaching roles; (c) participants were able to realize more ways AI can be useful to them in daily tasks such as administrative work, grading, and lesson-planning; and (d) workshops were effective in dispelling common misconceptions about AI use in schools. More participants indicated they had experience using AI in their posttests than in their pre-tests, so the workshops effectively targeted inexperienced users and provided them with sufficient AI experience. The tasks included in these workshops seem to give a well-rounded understanding and experience with AI to all participants. Pre-service and in-service teachers had the opportunity to study the use of an AI tool to generate content- and grade-level-specific lesson plans, and score the lesson plans according to rubrics used for teacher evaluation in Tennessee school districts. Results suggest the best fidelity of elementary-grades lesson plans generated through AI is in the area of science.

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The Institutional Review Board of the University of Tennessee at Chattanooga (FWA00004149) has approved this research project #24-066.

Beyond the Silo: A Content Analysis of Siloed STEM Education Journals

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Background and Significance

STEM is a central focus of contemporary educational research. Definitions and approaches to STEM vary widely across professional and academic circles as evidenced by STEM vision statements published by various organizations. The overarching research question for this content analysis was: How has STEM education been conceptualized in recent scholarship across four leading discipline-specific education journals representing each STEM field from 2022 to 2024? By examining the degree of integrative versus siloed approaches to STEM education research and the inclusion of equity and community engagement, the study revealed critical gaps in the current understanding of STEM education's framing and priorities.

Methods

We conducted a systematic content analysis of articles published during 2022–2024 across one major education journal per STEM discipline: Journal of Research in Science Teaching, Journal of Research in Technology Education, Journal of Engineering Technology, and Journal for Research in Mathematics Education. A total of 504 articles were coded with a priori codes using constant comparison for whether they: addressed multiple STEM fields (integrated STEM), focused on specific educational levels (PreK–graduate), included at-risk populations or persons with disabilities, referenced local community connections, embedded mathematics beyond merely as a supporting tool, inclusion of AI-related topics, types of research methodologies, geographic location of studies, participant demographics, and the integration of theoretical frameworks. The codes were then recorded in a shared spreadsheet and analyzed by creating pivot tables using variables that connected to each research question.

Findings

The analysis illustrated that the most recently published research has treated STEM as separate, siloed disciplines, with fully integrated approaches being relatively rare. Coverage across the educational spectrum was uneven, and inclusion of at-risk students and those with disabilities was notably limited. Community-linked STEM activities were seldom explored. Mathematics frequently appeared as a utilitarian tool rather than a deeply integrated field. Study of artificial intelligence in STEM fields was uncommon as well. Further variation emerged among journals regarding methodological approaches, degree of participant diversity, geographic representation, and use of theoretical grounding.

Conclusion

This study underscored the need to move beyond siloed conceptions of STEM education toward more integrative and equity-centered frameworks. The limited presence of research engaging underrepresented groups, community contexts, and meaningful roles for mathematics point to critical gaps. The gaps in inclusion of relevant and rising technology topics, such as artificial intelligence in STEM areas, also indicated a gap in research. We recommend future scholarship adopt holistic, inclusive models that advance interdisciplinary collaboration, equitable access, and connections between STEM learning and students' communities.

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Bridging the Gap Between STEM Teaching and Student Perspectives

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Brief Overview of Background Literature

In recent years, the field of STEM education has seen a call to increase efforts to reform instructors and delivery of curriculum to more student-centered and inclusive models and frameworks. Some recent initiatives call for undergraduate classrooms in the STEM field to include new foundational components such as active learning, interdisciplinary thinking, and the inclusion of more scientific research processes (AAAS, 2011). In support of this shift, a metanalysis of over 200 studies has found that active learning in the undergraduate classroom significantly improves student academic performance while reducing student failure rates in the undergraduate STEM classroom (Freeman et al. 2014). This highlights that while active learning enhances outcomes, it is equally critical to consider the underlying psychological environment supporting these practices.

Despite the efforts of reforming STEM education, many students still report that their learning environments lack the necessary core psychological support to thrive, suggesting a persistent gap between how professors interpret their teachings and reforms towards students and how students view them as being taught. Studies indicate that while they perceive themselves as adapting to students and adopting instructional strategies for the wellness of the student, students often report feeling disconnected or overwhelmed in the classroom while being unheard (Cooper et al., 2017; Canning et al., 2019). These disconnects between students and instructors lead to the idea that modification of teaching practices may not always translate into perceived core psychological support of needs from the perspective of the student.

To gain a clearer understanding of how classroom culture influences student motivation and learning, researchers have looked more to Self-Determination Theory (SDT) (Deci & Ryan, 2000). SDT indicates that individuals are most likely to experience intrinsic motivation and positive psychological well-being when three core psychological needs are met: competence (feeling capable and effective in what you do), autonomy (acting with choice and self-direction), and relatedness (feeling connected and supported by others). Instructors who actively support or adapt to support these needs can foster an environment where students are increasingly motivated and engaged. Jang, Reeves, and Deci (2010) found that strategies that support autonomy increase engagement and motivation across disciplines, while Skinner & Belmont (1993) saw that instructor behavior strongly plays into student influence and responses to learning. When these needs are supported, students show higher engagement, persistence, and academic performance

(Ryan & Deci, 2020), demonstrating the value of integrating psychological support with instructional reform.

Significance of Research

The research aims to bridge a gap in STEM education research by providing student perspectives of instructional support to foster a classroom where the psychological needs of competence, autonomy, and relatedness are met within a STEM department/college of a university. By providing the student perspectives of both STEM and non-STEM students taking STEM courses, we can provide a new scope of perspective into how classroom culture is fostered. With the known benefits of supporting student psychological needs leading to more engagement and motivation in the classroom (Deci & Ryan, 2000; Canning et al., 2019), gaining real insight into student perspectives can provide an additional field of information for both faculty and college personnel to pull from when designing curricula and methods for teaching and to ideally provide a joint set of data combined with instructor perspectives to have a broader idea of where the college stands in supporting psychological needs.

The result will yield a scalable product that can be applied to other institutions to gauge student perception of instructional support of psychological needs in the classroom. Recent publications, such as work by Tripp et al. (2025), have further extended these ideas into the undergraduate STEM setting, further showing the effects of positive support of psychological needs in the undergraduate STEM classroom. Findings from this study could inform departmental decisions, faculty development, and instructional design aimed at creating autonomy-supportive and competence-building learning environments.

Research Question

This study looks to explore how students perceive how instructors support their core psychological needs of competence, autonomy, and relatedness in the classroom. We look to specifically answer two research questions: how students perceive their instructors' support for competence, autonomy, and relatedness, and what students desire from instructors to better support these psychological needs. While most studies focus on instructors and their perceptions via surveys, focus group interviews, and performance metrics via college/departmental data, this study focuses on the perceptions from the student perspective. The participants range from a wide array of backgrounds, educational standings, and career goals. This student-centered approach helps reveal alignment or misalignment between instructor intentions and student experiences, greatly widening the scope of continued research into changing the culture of STEM field education, from instructors who have specialized degrees and concentrations to now include students who have had many different educational backgrounds and aspirations.

Methods for data collection, data analysis and findings

For our research questions, a modified version of the Basic Psychological Needs Satisfaction and Frustration Scale (BPNSFS) will be sent out to students enrolled in courses in seven select departments of Middle Tennessee State University's (MTSU) College of Basic and Applied Sciences (CBAS). The participating departments are Aerospace, Agriculture, Biology, Chemistry, Geosciences, Mathematics, and Physics. The survey is 24 questions and has been adapted to fit the lens of trying to explore student perspectives of instructor support of core psychological needs. Participants will be recruited through departmental email lists and course announcements, and participation will be voluntary and anonymous.

Data will be analyzed using Microsoft Excel, and descriptive statistics will be calculated to identify patterns and trends in student perceptions. Excel will be used for descriptive statistics because of its accessibility for early-stage data analysis. Mean scores and standard deviations will be calculated for each subscale (competence, autonomy, relatedness), and comparisons may be made across departments and class standings to identify notable differences. Approximately 300 responses are anticipated. While the research is still in its infancy, we anticipate seeing results well before the SSERC conference and having them analyzed and fully prepared by the date of the conference to share as aggregated departmental summaries and illustrative case examples. We expect this study to reveal how effectively instructors are supporting students' psychological needs in STEM courses and to identify specific areas where additional support could enhance students' motivation and sense of belonging.

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Climate Change Beliefs and Learning Outcomes in Undergraduate Education: Insights from the CLUE Curriculum

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Background and Literature Review

It is important to increase college students' climate literacy to meet the challenge of global environmental issues and to make informed decisions (Anderson, 2012; Shepardson et al., 2017). Despite widespread public exposure to climate data, there are misconceptions, with some of the most conspicuous issues relating to causes and effects of anthropogenic climate change (Leiserowitz et al., 2022). Studies in education have shown that formal, inquiry-based learning tasks can significantly improve students' conceptual understanding of climate processes and improve their acceptance of human influence on climate (McNeal et al., 2014; Kahan et al., 2015).

But there are different perceptions of climate change institutionally and geographically. Student attitudes are representative of the broader sociocultural and political context, and conservative or rural students would be more inclined to question anthropogenic climate change than coastal or urban students (Howell & Allen, 2017; Mervine et al., 2020). This difference implies that there is a necessity to study the impact of local context and educational environment on the acceptability of students to climate science.

The Climate Literacy in Undergraduate Education (CLUE) project was set up to integrate climate literacy into two-year and four-year general science courses in general education. Curriculum emphasizes experiential data collection, such as personal temperature and humidity measurement, and guided reflection on climate processes. Pre- and post-intervention and one-month post-intervention surveys assess students' knowledge, perceptions, and attitudes toward climate change.

Significance of the Study

Comparative analysis back to differences in climate change attitudes among Middle Tennessee State University (MTSU) students, a large public four-year institution in the southeast United States, and Pasadena City College (PCC) students, a two-year community college in southern California. These institutions offer a good comparison: MTSU's student body is a region where climate skepticism is more prevalent, while PCC is in a state with high environmental policy and climate education. Showing how students' knowledge and attitudes vary between these environments has the potential to expose how environmental and educational contexts shape climate literacy outcomes.

By recording impacts on students' acceptances of anthropogenic climate change and self-efficacy in what they know, the research joins efforts to make climate education more specific to diverse populations. Such results can recommend that efforts enhance public climate literacy, resilience planning, and fair access to environmental education resources.

Methods and Data Analysis

Survey data were collected from undergraduate students in the CLUE program at MTSU (n =

564) and PCC (n = 46). All respondents completed three surveys. Pre-program, post-program, and one-month post-program that consisted of Likert-scale items that measured climate knowledge, perceived understanding, concern, and acceptance of anthropogenic climate change.

MTSU data had to be cleaned and preprocessed before analysis. Non-consenting participants were dropped, duplicate entries in the surveys were eliminated, and similar participant identifiers were used to pair pre- and post-responses. The cleaned data sets were consented, non-duplicate data for each survey, and paired pre/post responses for longitudinal analysis. PCC data were clean and ready for analysis.

Quantitative analysis will include descriptive statistics, mean Likert-score comparison, and inferential tests (t-tests and ANOVAs) to identify institution and across-timepoints variations. Exploratory correlations will investigate confidence in climate knowledge, acceptance of human causation, and perceived relevance of climate change. Visualization with Likert bar charts will display attitude changes and retention of knowledge throughout the program.

Results and Discussion

Initially, the results showed that students at both colleges improved their climate knowledge following exposure to the CLUE program. However, consistent with earlier research (Howell & Allen, 2017; Leiserowitz et al., 2022), responses show noticeable regional variation. Students at PCC showed greater anthropogenic climate change endorsement and greater confidence in what they know, while MTSU respondents were more variable and had a higher propensity for believing climate change is a natural phenomenon.

These findings suggest that while educational interventions such as CLUE are effective in promoting knowledge, the size of attitude change can be affected by the larger sociocultural environment. The environment of the two-year college compared to four-year university can also affect outcomes because community college students represent more heterogeneous socioeconomic and cultural backgrounds and potentially may be differentially motivated to acquire information about the environment. Further statistical analysis will also clarify to what extent differential outcomes are either an education context, location, or community belief function.

Conclusions and Implications

The contrasts between MTSU and PCC indicate the complex interconnection between education, regional culture, and environmental context in shaping climate literacy. The CLUE program shows that active learning approaches can be effective at engaging students' comprehension of climate in different institutions, but attitudinal change may require contextualized instruction that resonates with students' lives.

Future studies will broaden this comparison to additional institutions and incorporate qualitative responses to better ensnare the thinking of students. Results will inform continued work to improve climate literacy curricula and construct regionally responsive approaches to climate change communication and education.

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College Students' Perceptions of Race:
Exploring Relationships Between Culture, Genetics, Evolution, and Undergraduate Biology Instruction

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Abstract: Evolution and genetics are central topics in biology education that can both create and correct misunderstandings about race. People may believe there are significant biological differences between races, but evolution and genetics can illuminate the shared ancestry and close genetic relationship between all human populations. In biology, races are defined as populations that are genetically distinct from one another (Futuyma, 1986; Mayr, 1982). Yet, compared to many other species, humans lack genetic variation, and there are no clear genetic divisions consistent with the racial categories used in society (Graves & Goodman, 2021). Evidence from evolution also supports a single human race. While traits such as skin color are influenced by genetics, they mainly reflect ancestral adaptation to sunlight exposure depending on distance from the equator (Jablonski, 2021). Similar skin tones do not mean people are more closely related genetically. For example, both Sub-Saharan Africans and Melanesians from the Solomon Islands have dark skin, but genetic evidence suggests that Solomon Islanders are more closely related to Europeans than to Sub-Saharan Africans (Nielsen et al., 2017). Yet, both groups are often categorized as "Black" in society, showing how social ideas about race differ from biological reality. Evolution also emphasizes the close shared ancestry of all humans originating from Africa approximately 200,000 years ago. As a result, biologists and anthropologists have attempted to clarify that race is not a biological reality but is instead rooted in cultural norms and social practices. Yet, we know little about how, if at all, the intersection of evolution, genetics, and race are currently taught in undergraduate biology classes and whether teaching practices help reduce or unintentionally reinforce misconceptions.

This gap presents a challenge for science education. When students enter biology classrooms, they may carry social understandings of race that do not align with biological evidence. If courses do not explicitly address these differences, students may continue to rely on misconceptions even while studying evolution and genetics. Avoiding discussion of race in biology may unintentionally reinforce harmful misunderstandings, as students fill in gaps with cultural narratives rather than scientific evidence. Conversely, integrating explicit discussions of race, genetics, and evolution into biology education can provide opportunities to challenge stereotypes, correct misconceptions, and deepen students' scientific understanding of human variation. At the same time, students are often aware that evolution has historically been misapplied to support racist ideas, which can shape how they interpret evolutionary concepts in the classroom (Bailey et al., 2011; Brem et al., 2003). For example, Rice et al. (2025) found that, in a study of 672 undergraduate biology students, 36 percent perceived that the concept of evolution contributes to racism. Students cited commonly used evolutionary terms such as "survival of the fittest," "primitive," "less evolved," and "fitness" as contributing to negative or

racially charged interpretations. In reality, evolution more accurately illustrates the shared origins of humans and our overall genetic similarity rather than sharp divisions among populations.

This study will examine undergraduate biology students' conceptions of race at the intersection of evolution, genetics, and culture and how they have learned about these topics in their coursework. To guide this study, we developed the following research questions:

1. How do students define "race," and what do they know about how "race" is defined in biology?
2. In what ways do students think human racial differences are genetic or cultural?
3. What are students' experiences learning about race and evolution in biology courses, and how have these experiences influenced their perceptions of race?
4. What are students' suggestions for improving biology and evolution education about race?

We designed a semi-structured interview protocol to explore these questions and in fall 2025 will interview ~30 students from different racial backgrounds who have completed introductory biology courses. Each interview will last about one hour. We will then use inductive thematic analysis to identify patterns in how students think about race, genetics, evolution, and vulture as well as how these ideas are discussed in their classes. We expect that many students will be unaware about the differences in how race is defined in biology versus society and will hold variable conceptions of race as being genetically versus culturally determined. Further, we predict that students rarely encounter instruction about race in their biology courses. By January 2026, we will have conducted our preliminary thematic coding to present results for feedback.

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Developing Data Science Through Community Engagement: MVP Model

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Introduction

The *Mathematizing, Visualizing, and Power (MVP): Appalachian Youth Becoming Data Artists for Community Learning* project is a three-year initiative to foster youth engagement with data science in East Tennessee's Appalachian communities. The MVP project, informed by the work of D'Ignazio & Klein (2020), Stornaiuolo (2020), and Wilkerson et al. (2021), is grounded in a community-centered model, focusing on equipping young people (ages 11-18) to become data artists who analyze and create visualizations that reflect local and regional community issues. The core aim of the MVP model is to enhance STEM engagement through informal learning, leveraging data science as both a tool for youth empowerment and community transformation.

Research Questions

The study is guided by three primary research questions:

1. How does engagement with data science through MVP impact youth identities and their roles in the community?
2. What learning opportunities does the MVP model afford community members during interactions with youth-led data visualizations?
3. How do participants' interactions within the MVP model influence their understanding and perceptions of data in relation to local issues?

Methodology and Timeline

The MVP model (Fig. 3) is structured around iterative design research cycles (Cobb et al., 2003). The project includes two main components: Learning Sessions (LSs) and Community Learning Events (CLEs). Learning sessions provide a space for youth to explore data context, variability, and visualization over a 14-week period, while CLEs offer community members opportunities to engage with youth-led visualizations (Wilkerson & Polman, 2020; Rubel et al., 2021).

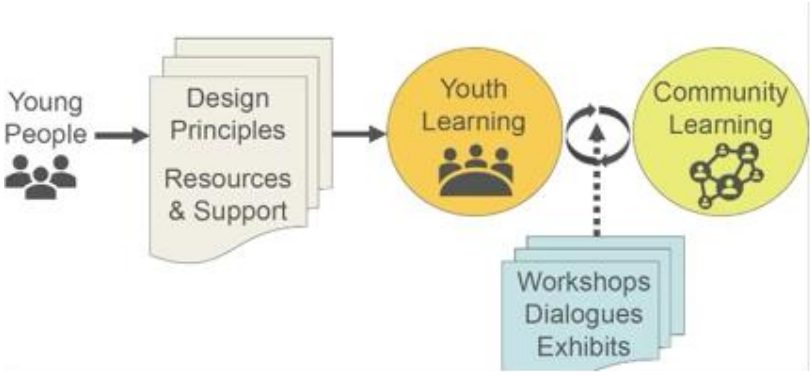


Figure 3. MVP Theory of Action.

In 2023, the pilot cycle (Cycle 1) was implemented with 15 students across rural and urban contexts. The field tests included cycles 2-4 that expanded over fall 2023 through summer 2024, with participation ranging between 18 - 49 students across two sites (Cycle 3), refining both youth and community learning experiences. Currently, data collected through field notes, surveys, interviews, and portfolio artifacts is being analyzed to measure shifts in youth identity, data literacy, and community engagement.

Results

The research team is actively working on a number of analyses related to youth positioning, community learning, and design-based research. While findings are still being finalized, preliminary analyses indicate that youth develop a sense of ownership over data visualizations, with increased confidence in presenting data narratives that reflect community challenges. Some community members' participation in CLEs demonstrated a growing interest in data-driven discussions on local issues, aligning with the project's goals of fostering equitable learning spaces that amplify underrepresented voices (Philip et al., 2016; Taylor, 2020).

Conclusion

The MVP project underscores the potential of informal STEM education to foster youth leadership and community engagement through data science. By positioning youth as both learners and leaders, the MVP model advances STEM education and broadens participation within underrepresented Appalachian communities, contributing to a humanistic approach to data science education that emphasizes personal, social, and cultural dimensions (Rubin, 2020; D'Ignazio & Klein, 2020). Findings will contribute to developing an adaptable framework that can be implemented in similar contexts.

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Development of Computational Thinking using TI-Innovation Rovers in High School Mathematics

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Introduction:

As computational thinking (CT) becomes an essential skill in education, it is important to explore how robotics and programming can be incorporated into high school mathematics to foster these skills and make cross-curricular connections. Computational thinking, which includes decomposition, pattern recognition, and algorithmic thinking, is critical for problem-solving across STEM fields (Wing, 2006).

However, limited research has been conducted on the development of CT within the context of

Algebra 2 and Pre-Calculus. This study examines how a programmable robot controlled by a TI-Nspire calculator, specifically the TI-Innovator Rover, can be integrated into Algebra 2 and Pre-Calculus lessons to promote student mastery of content-specific concepts.

Research Questions:

This study addresses the following questions:

- How does the integration of TI-Innovator Rovers foster computational thinking skills in the context of learning algebraic concepts?
- Which computational thinking components (decomposition, pattern recognition, and algorithmic thinking) are most enhanced through programming the TI-Rovers?
- What challenges do students encounter when developing computational thinking through Rover programming tasks?

Methodology and Timeline:

The lessons for this study were implemented intermittently over a semester in the author's high school Algebra 2 and Pre-Calculus classroom. Students participated in problem-solving tasks that required programming the TI-Innovator Rovers to model mathematical concepts, such as quadratic functions and parametric equations. Data was collected from student coding reflection logs, classroom observations, rubric assessments of computational thinking, and student self-assessment. Student coding reflection logs and observational notes provided qualitative data on students' problem-solving approaches, while rubric scores and self-assessments offered quantitative insights into computational thinking development. The timeline included:

- Weeks 1-3: Introduction to TI-Innovator Rovers and foundational programming skills.
- Weeks 4-16: Various problem-solving tasks focused on mathematical concepts and computational thinking skills.
- Weeks 17-18: Final assessments and data collection.

Data Analysis & Results:

At the time of this submission, the lessons are currently being taught in the Algebra 2 and Pre-Calculus classes. Once the semester ends, the data will be analyzed using a combination of qualitative and quantitative approaches. The student's coding reflection logs will be examined to track progress in decomposition, pattern recognition, and algorithmic thinking, while observational teacher notes provide context for student behaviors during problem-solving tasks. Quantitative data from rubric scores and self-assessments will be analyzed for trends in CT development.

The findings may reveal that the integration of TI-Innovator Rovers enhances a student's computational thinking. It is hypothesized that students will be able to break down complex mathematical problems and develop structured, logical sequences of instructions to program the TI-Rovers. Challenges and struggles with the lessons, student experience, and teacher experience will be noted.

Conclusion:

This study will demonstrate the potential for programmable robotics, such as the TI-Innovator Rovers, to enhance computational thinking in high school mathematics classrooms. The findings may support the inclusion of robotics and programming in math curricula to better prepare students for the demands of STEM fields. Future research could explore methods to improve pattern recognition and further investigate how CT can be developed through interdisciplinary approaches in secondary education.

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Linking Research and Practice: This research for a poster links research and practice by exploring how TI-Innovator Rovers, programmable robots controlled by TI calculators, can enhance both computational thinking (CT) and mathematical problem-solving in high school classrooms. The session is highly relevant to both research and practice communities as it demonstrates the integration of robotics and programming into math instruction, offering insights into cross-curricular STEM applications.

For researchers, the session investigates the development of key computational thinking components (decomposition, pattern recognition, and algorithmic thinking) through hands-on activities in Algebra 2 and Pre-Calculus. The data collection and analysis methods, including coding reflection logs and rubric assessments, will generate empirical evidence about CT development in math education, filling a gap in the existing literature.

By connecting research findings with classroom applications, this session encourages collaboration between educators and researchers, providing valuable insights for both communities.

Development of Inclusive STEM Curriculum Using Data Science Innovations of W.E.B. Du Bois to Promote Diversity in Science

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Although research indicates that professions involving science, technology, engineering, and mathematics (STEM) education have large payoffs for students because they have been associated with high incomes and high-status jobs (Xie, Fang, and Shauman 2015), Only 20% of STEM degrees are conferred to Black, Latinx, and female students. Therefore, these populations remain underrepresented in STEM and data science fields. The exclusion of pathbreaking scholars from underrepresented communities within STEM curriculum contributes to the omission of underrepresented role models and reinforces STEM as a space for mostly white men. A recent study by Riegle-Crumb, King, and Irizarry (2019) found that Black and Latinx students were more likely to change their majors or pursue majors in other fields.

Underrepresented racial/ethnic minorities do have lower enrollment in STEM fields and classes because of cognitive or aspirational differences. Structural racism and long-standing practices maintaining the status quo cultivate experiences of isolation, exclusion, or cultural mismatch for said students within STEM education, which leads to lower enrollment (Chang et al. 2014; McGee 2020; Xie et al. 2015; McGee et al. 2019; McGee et al. 2021). Impostor syndrome and stereotype threat among underrepresented racial/ethnic minorities is the result of racist environments (McGee et al. 2019; McGee et al. 2021) Psychologists explain stereotype threat as a process where individuals identifying with a marginalized status (including women and Black and Latinx communities) have lower performance outcomes because of the presence of a negative stereotype. Furthermore, in academic environments that are either racially imbalanced or that lack positive representations of racialized groups, stereotype threat is more likely to lead to worse outcomes for racialized minorities in STEM. We argue that the absence of underrepresented role models and authors within the STEM curriculum may contribute to underrepresented students choosing non-STEM majors and having lower STEM-related performance outcomes

Conversely, Lee and Zhou (2015) found that stereotypes can be deployed to improve the outcomes of underrepresented minority students. For example, when positive stereotypes are associated with racialized groups, they may receive a boost of confidence and teachers may offer tangible (tutoring and additional help) and intangible (benefit of the doubt, encouragement) resources that can benefit struggling students. We contend inclusion of key figures of color may operate as a similar stereotype boost.

Higher education is the foundation for how students will integrate knowledge into our society, directly impacting the near future. Science, technology, engineering, and math (STEM) curriculum can impact future student engagement in science careers and fields. The Du Bois science education research visualization and empowerment (SERVE) project is a collaborative research initiative to build an effective inclusive curriculum for STEM and data science.

The 1-2 session module is designed to facilitate racial and ethnic minority students to explore core research methods and data visualization concepts that can be taught through the creative approach of social scientist W.E.B. Du Bois. By centering Du Bois' innovative approach to visualizing social data, the module aims to deepen student engagement in STEM disciplines and promote them to STEM careers using stereotype boosting methods. Specifically, our research question is does incorporating Du Bois centered teaching modules improve interest participation, and performance of underrepresented racial and ethnic minority students in STEM?

The Du Bois visualization module has been designed through a collaborative approach between three higher education institutions, UC Merced, Fisk University and Princeton University, each with different student demographics. Specifically, Hispanic Serving Institution (HSI) (University of California Merced), an Ivy League, Historically Black College, and University (HBCU) (Fisk University), and Primarily White Institution (PWI) (Princeton University). Each institution participates in the writing, creative development, and constant revision of the module. The module design includes (1) context: to give insight on the work of DuBois (2) explore: to critically engage in the data and charts (3) content: to apply in modern context. The module covers one-week of course time, typically delivered across three 50-minute classes or lab sessions, and includes three independent assignments. The platform allows faculty to internalize the module to structure implementation in their courses. While the module is designed with statistics and data science courses, we are also engaged in social science courses.

This experiment uses a pre-test/post-test design to evaluate the impact of modules amongst students. Instructors are participating in repeated measures in which they will participate in the treatment group and one semester in the control group. The students, across the three partner institutions, will be administered through a pre- and post-test survey. The survey results will identify if there is a relevant comparison between the students' engagement with science education- and inform where the Du Bois module can make revisions for the broader curriculum development. Additionally, the module will be revised in real-time based on the campus feedback. Both students and faculty participants are invited to join focus groups to share their experience with science education. The faculty participants also engage in table discussions and debrief to reflect on the module and offer feedback on its design. Survey findings will be compared to student demographic data from participating institutions.

The data collection is still in the preliminary stages. However, initial findings from student and faculty focus groups indicate a gap: students feel distant from DuBois and struggle to see creative value in their STEM courses, while faculty recognize the absence of creativity in STEM curriculum but are uncertain about how to find them. However, faculty participants agree with Du Bois' approach to racial justice is useful to teaching data visualization- especially with integrating creative opportunities like art and interactive coding exercises. These findings highlight the need to develop and share a foundational curriculum like the Du Bois module to enrich the STEM education experience.

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Empowering Students to Think Like Scientists:
A Modular Yeast Stress Response Activity

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Undergraduate research experiences have been shown to increase students experience with the scientific process, increase students' self-efficacy in science, increase persistence in science majors, and inform students career goals. However, traditional mentored research positions where students work in faculty research labs, are rare and difficult to find. Course-based undergraduate research experiences (CUREs) provide a way for many students to gain the benefits of authentic research. We developed a CURE using yeast stress response designed to promote critical thinking, student ownership, scientific reasoning, and hypothesis-driven experimentation. The project emphasizes experimental design in which students choose stress conditions to test, design an initial screen using spot dilution plates, then scale up the experiment to observe and measure changes in cell concentration with increasing levels of stressor or increasing time. Students decide the concentration ranges of the stressors, temperatures for heat or cold stress, and the data collection method. After the initial experiment, students iterate and revise their experiment which mirrors real research practices. This CURE also integrates quantitative reasoning with dilution math, concentration calculations, and analyzing growth curves. This project is low-cost and accessible, making the activity scalable across institutions. Finally, it is a short (~3 week) module that can be added to a course to introduce students to authentic research without overhauling an entire course. We assessed the impact of this CURE on students' confidence and competence in conducting key aspects of scientific research. Our findings indicate significant improvements in students' self-efficacy related to research skills, as well as their understanding and application of the scientific method.

Exploring Science Identity in Biology Education: A Scoping Review

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Study Context

Over the past two decades, science identity has emerged as a critical construct in STEM education research, used to explain persistence, belonging, and academic achievement (Carlone & Johnson, 2007; Hazari et al., 2013). Biology offers a unique disciplinary context for identity development. Biology identities frequently emerge through authentic research experiences, field courses, and laboratory practices. For example, course-based undergraduate research experiences (CUREs) and marine biology field programs have been shown to cultivate biology identity by situating students in the roles, practices, and values of working biologists (Stanfield et al., 2022; Zhang et al.,2025; Carrier, 2021). Similarly, field biology courses narrow achievement gaps by fostering a sense of belonging and professional social connections not always accessible in classroom-based disciplines (Beltran et al., 2020; Esparza et al., 2023).

Researchers have conceptualized biology identity as both an extension of general science identity and as a distinct disciplinary formation. While Carlone & Johnson's (2007) three dimensions (competence, performance, and recognition) are widely applied, biology identity studies often expand these dimensions to include ways of thinking ecologically, perceptions of what it means to be a scientist, and how students interpret and respond to experiences of failure in context (Ambrosino et al., 2023). These additions highlight how biology identity is uniquely shaped by disciplinary practices and cultures, which emphasize collaborative fieldwork. While the construct has become widely adopted, its conceptualization and operationalization remain inconsistent, with disciplinary differences often obscured under the broad umbrella of "science identity."

Significance of the research

As the use of the term has expanded, so too has conceptual ambiguity and inconsistency in its application, particularly within post-secondary contexts. Operationally, biology identity has been measured in varied ways: treating science identity as a predictor variable or an outcome in scientific experiences; measuring it on a scale of either high or low versus something that can be cultivated overtime which is inherent (Chen et al., 2021; Ambrosino & Rivera., 2022; Camacho et al., 2021). These approaches reflect the richness of biology identity work but also expose the operational inconsistencies that challenge cross-study comparisons.

As such, a scoping review focusing on biology identity as a discipline-based identity is warranted. Such an approach will clarify conceptual ambiguity, reveal operational inconsistencies, and highlight the distinctive role of biology-specific experiences in shaping persistence and belonging in STEM. In doing so, it will not only advance theory but also inform the design of biology programs and scholarships that explicitly cultivate disciplinary identities.

Research questions

1. How has the construct of science identity been **conceptualized** within discipline-based biology education at the post-secondary level?
2. How has the construct of science identity been **operationalized** within discipline-based biology education at the post-secondary level?
3. In what ways do the conceptualization and operationalization of science identity in biology education differ from or align with approaches in other STEM disciplines?

Data analysis procedures

This study uses a scoping review design to map how researchers have conceptualized and operationalized biology identity (a discipline-based science identity) in higher education. A scoping review is appropriate because the aim is to explore the breadth, nature, and gaps of literature. The review follows established frameworks for scoping reviews (Arksey & O'Malley, 2005; Colquhoun & O'Brien, 2010) and the PRISMA-ScR reporting checklist. To identify relevant literature, we conducted a systematic search across major databases with a focus on science identity at postsecondary STEM education. The primary search engines used were google scholar and Scopus education for its broad coverage of peer-reviewed journals in education and STEM fields. Additional exploratory searches were performed at the top journals: CBE- Life Sciences, Journal of research in science teaching, international journal of STEM education, Science education and international journal of science to ensure coverage of recent and interdisciplinary work. The search strategy combined keywords and Boolean operators to capture research at the intersection of "science identity", "STEM identity", and "post-secondary STEM education". Studies were included if they: Focused on science identity or STEM identity OR scientist identity (engineering, physics, computer science, chemistry and biology identities) in postsecondary STEM education, Employed qualitative, quantitative, or mixed methods that explicitly conceptualized and/or operationalized science identity, Were peer-reviewed journal articles published in English, Published between 2007-2025 (from 2007 because of the ground breaking conceptualization paper by Carlone and Johnson, 2007). After screening papers that fit our inclusion criteria, we had 547 papers. Further screening was done to sort out papers that explicitly studied science identity in biology education context. The selected articles (41) were analyzed using both descriptive and theoretical coding, allowing for the identification of themes regarding how science identity is conceptualized and operationalized.

Summary of findings

Here we present pre-liminary findings from our initial reviews. However, results of a deeper review of the literature will be presented at the conference. That being said, the initial scoping review revealed that biology identity in higher education is conceptualized by three interrelated themes: community, attitudes, and authenticity which aligns with Vincent-Ruz and Schunn's (2018) conceptualization of what drives science identity: *a sense of community and affiliation* (Carlone and Johnson, 2007), *built by consistent extrinsic and intrinsic attitudinal factors*

(Aschbacher et al., 2010), and *a match between school science and real science* (Archer et al., 2010). The reviewed literature showed that a sense of belonging, and recognition is fostered through field courses, mentoring, and place-based research programs that create professional networks and validate students' participation in science (Beltran et al., 2020; Esparza & Smith, 2023; Carrier, 2020). Both intrinsic motivations (curiosity about living systems, ecological commitment, biomedical relevance) and extrinsic support (mentorship, representation, cultural capital) drive persistence, though barriers such as stereotypes of scientists and experiences of failure can weaken identity development (Ahern-Dodson et al., 2020; Camacho et al., 2021, Zhang et al., 2025). Importantly, biology identity grows strongest when classroom learning aligns with "real science" practices: authentic research, lab work, field biology, and course-based research experiences consistently help students see themselves as "biology people" (Anthony et al., 2017; Ambrosino & Rivera, 2022; Dunbar-Wallis et al., 2024). Unlike physics or engineering, where abstraction and problem-solving dominate (Hazari et al., 2020), biology identity is uniquely tied to visible disciplinary practices and authentic engagement with ecosystems, organisms, and biomedical research, making community and authenticity central to how identity is conceptualized and operationalized in this field.

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From Framework to Fulfillment: Investigating Scrum's Role in Supporting Motivation through Self-Determination Theory

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Brief Overview of the Background Literature

Agile frameworks have become increasingly common across industries as strategies for improving collaboration, efficiency, and productivity. Among these, Scrum is one of the most widely recognized and adopted, originally designed to address challenges in software development. *The Scrum Guide* provides a detailed structure for organizing teamwork through defined roles, formal events, and key artifacts. In Scrum, a sprint begins with sprint planning, where the team defines a goal and selects work to deliver; continues with the daily Scrum, where progress is inspected and adjustments are made; moves into the sprint review, where the increment is demonstrated and feedback is gathered; and concludes with the sprint retrospective, where the team reflects on the sprint and identifies improvements for the next cycle. Central to the framework are the empirical pillars of transparency, inspection, and adaptation, as well as five core values: commitment, focus, openness, respect, and courage (Schwaber & Sutherlin, 2020). The underlying claim of the guide is that when followed fully, Scrum helps teams produce better outcomes by making problems visible and by fostering trust, collaboration, and accountability.

In 2024, A STEM education research team at a large public R2 university, composed of three principal investigators (from biology, mathematics, and chemistry), two postdoctoral scholars, three graduate researchers, two undergraduate researchers, and a project manager, chose to adapt the Scrum framework to fit the needs of the team. Initially, Scrum was introduced to enhance collaboration, productivity, and project outcomes. However, after a year of practice, the team recognized that Scrum was not only improving the workflow but also appeared to be supporting their psychological needs as researchers. This led us to develop a formal research project to explore this phenomenon.

The Scrum Guide largely describes what teams should do and what benefits should follow, without grounding these recommendations in an explicit theoretical framework that explains *how* these practices lead to improved outcomes. Recent research in STEM education points to **self-determination theory (SDT)** as a useful lens for investigating this gap (Ryan & Deci, 2017). SDT suggests that motivation to accomplish tasks can occur when three basic psychological needs are met: autonomy (a sense of control over one's actions), competence (a sense of mastery and effectiveness), and relatedness (a sense of belonging and connection).

When these needs are fulfilled, individuals are more intrinsically motivated, leading to wellbeing and stronger outcomes across a variety of contexts. Additional studies such as Ochoa & Reynolds (2022), Hidalgo (2019), and Hicks & Foster (2010) have noted how their unique teams have adapted Scrum for academic and research purposes; however, the relationship between Scrum and SDT as a mechanism for how Scrum enhances productivity has not been explicitly studied.

The Significance of the Research

This research contributes to both agile practice and theory by reframing Scrum not only as a tool for improving project outcomes, but also as a framework with potential to foster the motivation and well-being of team members. By grounding Scrum's effectiveness in self-determination theory, we aimed to provide a theoretically informed explanation for how Scrum may impact both individual motivation and collective performance. These insights are particularly significant for teams operating in contexts where full-time project dedication is not feasible, such as academic research groups, where members balance multiple responsibilities.

The findings can inform adaptations of Scrum that support both the needs of the project and the psychological needs of the people doing the work, ultimately leading to healthier, more motivated, and more productive teams.

Research Question

Our central research questions are: **(1) Which Scrum events and artifacts support which psychological needs of autonomy, competence, and relatedness? (2) In what ways do the various scrum events and artifacts support these needs?** Unlike the typical software development setting envisioned by *The Scrum Guide*, our education research team consists of faculty, staff, postdoctoral researchers, graduate students, and undergraduate assistants, most of whom dedicate only partial time to the project. This context required us to adapt several Scrum practices, such as sprint planning, sprint reviews, and retrospectives, while still striving to preserve the framework's intent. For example, daily scrums were replaced with alternative coordination mechanisms, and retrospectives were embedded into team evaluation surveys. These adaptations provide a unique opportunity to study Scrum in a nontraditional environment while testing how its core principles intersect with the fulfillment of psychological needs.

Data Analysis Procedures and Summary of Findings

Data for this study includes multiple sources: recordings and transcripts of team and sprint planning meetings, evaluation surveys designed to capture team members' experiences, and project artifacts documented within Microsoft Planner. These materials will be analyzed using a coding framework aligned with self-determination theory, allowing us to systematically assess the extent to which Scrum events, values, and adaptations contribute to or constrain autonomy, competence, and relatedness. The analysis will proceed in two stages. First, researchers will deductively code for evidence of autonomy, competence, and relatedness across key Scrum events such as sprint planning, reviews, and retrospectives. Second, within each category, they

will inductively code to explore the specific ways in which these psychological needs are addressed.

As this project is still in its early stages, we present preliminary results here. The sprint planning meetings fostered autonomy, as participating team members shape the direction of upcoming tasks. The sprint reviews strengthened competency by providing a structured space for members to present and reflect on their accomplishments. Finally, the sprint retrospectives have deepened relatedness, as the team openly discusses what is working well and identifies opportunities for improvement. These results are expected to highlight which psychological needs are most strongly supported by different Scrum events and the mechanisms through which these needs contribute to team motivation and research productivity.

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Impact of Hands-On STEM Experiences on Student Science Self-Efficacy and Biological Concept Knowledge

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Literature Overview

It is thought that when attempting to engage students in STEM courses that hands-on experiences are an effective method. A variety of techniques may be employed. The effects of these instructional methods may be measured in students in two ways. The first method is to measure academic performance, analyzing conceptual assignment and test scores. The second method is by measuring student perceptions of their comfortability and/or success in the subject via survey responses. These methods have been employed to monitor a variety of hands-on instructional methods.

Significance

An identifiable gap in the literature is in the type of interventions. There are several observable instances of researchers involving students in brief workshops or summer workshops with sessions for students to choose from. There is a lack of research on the effects of consistent and prolonged participation in an actual research project with actual scientists. Our study aims to employ both content-based tests and survey methods to observe the effects of participation in a research project led by a college professor. Understanding how effective this intervention is will improve the understanding of how best to aid students in understanding and entering science as both a field and a process.

Research Questions

Does participation in a professional scientist-led, project-based learning experience significantly increase high school students' science self-efficacy compared to traditional instruction? Do students in the treatment group exhibit greater gains in biological knowledge than those in the control group?

Are there correlations between students' attitudes toward STEM, their sense of belonging in science, and their performance on biological content assessments?

Design

Randomized Controlled Trial Using a Blocked Design
Blocking Variable: Time of day (e.g., morning vs. afternoon classes).
Unit of Randomization: Class sections (e.g., Periods 1–6).
Assignment: Within each time block (e.g., AM/PM), class sections are randomly assigned to either the treatment or control group.

Groups

Treatment Group: Receives instruction through professional scientist-led project-based learning.
Control Group: Receives equivalent content through traditional teacher-led instruction.

Duration

45-minute block for 4–6 weeks

Science Self-Efficacy Survey

Validated instrument (e.g., Science Self-Efficacy Questionnaire for Secondary Students), administered pre- and post-intervention.

Biological Concept Knowledge Assessment

Content test aligned with state curriculum, administered pre- and post-intervention. .

Procedure

All students complete surveys and the content knowledge test prior to first intervention. On intervention days, experimental groups will engage with an ETSU professor on the research going on in their lab and help design and conduct current research with them. Students in the control group will participate in traditional instruction on the scientific methodology and famous scientific experiments. There will be 4 intervention days, the last being in December. The survey will be administered again after the second visit, after the final visit, and in April. The content test will be administered again in April.

Data Analysis

Two-Way ANCOVA
IV1: Instruction type (treatment vs. control)
IV2: Time of day (AM vs. PM)
DV1: Posttest self-efficacy (covariate = pretest score)
DV2: Posttest biological knowledge (covariate = pretest score)
Effect Size Calculations (e.g., partial eta squared or Cohen's d)

Summary of Findings

This study is currently underway. Data from the first year will be presented.

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Is it Okay for Teachers to Learn?
Psychological Safety as a Condition for Engagement in Professional Learning

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Literature Review

When people encounter social environments with the potential of threat or embarrassment, they tend to behave in ways that keep them from learning (Edmondson, 1999). In contrast, when people are comfortable with taking interpersonal risks within social environments because they feel safe, they are more likely to engage in the iterative process of learning (Edmondson, 1999). Edmondson (1999) defines team psychological safety as the shared belief held by members of a team that a team is safe for interpersonal risk taking. Team psychological safety has been extensively studied in other fields of research such as healthcare teams, corporations, and for-profit sectors. However, team psychological safety has not been adequately examined in educational research, especially in professional learning environments.

Understanding the mechanisms at which learning and motivation can be enhanced through safe social processes is valuable to the educational research field (Burgess et al., 2025). Considering teachers are expected to be continuous learners as instructors, exploring how teachers engage in professional learning environments would be beneficial to student instruction in K-12 educational settings. Understanding contagion processes can guide interventions to foster socially contagious motivation and well-being (Burgess et al., 2025), possibly advancing our understanding of how teachers learn from each other and their leaders in psychologically safe learning environments.

Psychological safety is the highest in schools with collaborative cultures and team-oriented leadership (Shahid & Din, 2021). According to Edmondson (1999), team leaders are especially important in establishing team psychological safety as team members pay close attention to the responsive behaviors of team leaders. Depending on whether the team leader displays supportive and collaborative behavior towards team members, team psychological safety may increase along with their learning behaviors (Edmondson, 1999). Collaboration must be deliberate, well-designed, and empowering to be effective in educational settings (Hargreaves, 2019). Collegial inquiry fuels professional growth by calling on schools to implement collaborative cultures within schools (Lovett, 2023). Examining how team leaders create the condition of team psychological safety in professional learning environments may inform how to better design professional development.

The Significance of the Research

According to Ghamrawi et al. (2023), poor wellbeing in teachers hinders their motivation to take on new roles and reduces their creativity in professional settings. In contrast, providing the appropriate conditions that include systemic supports for wellbeing may empower teachers to take on new roles and enhance their professional development (Ghamrawi et al., 2023). Increasing engagement in professional learning settings may positively impact how teachers implement improved teaching strategies and content knowledge (Zhang et al., 2024).

Because learning in teams requires some level of interpersonal risk, team psychological safety may be measurable by looking at the learning behavior of individual team members (Edmondson, 1999). According to Lovett (2023), leadership and learning function better when synchronized, which is especially meaningful to how teachers learn in professional environments and how their wellbeing is positively impacted through social interactions. Leadership behavior emphasizing people and tasks creates high levels of psychological safety among team members (Shahid & Din, 2021). Therefore, teachers are more likely to positively respond to their leaders' guidance if they experience psychological safety and overall wellbeing (Fleming et al., 2024). Positive feedback such as recognition, collaboration, and student success reinforce growth in professional learning environments (Poekert et al., 2016). These leadership behaviors often increase the learning behaviors of individuals as they seek feedback, are willing to experiment, and may discuss errors openly with other team members (Edmondson, 1999). Examining how leaders' behavior increases their teams' learning behavior, may increase the effectiveness of professional development, especially in collaborative learning environments. Woo et al. (2022) found that collaboration, more than coordination and cooperation, empowers teachers in meaningful decision-making, solidifying the need to investigate how team psychological safety impacts teachers in professional learning environments.

Research Questions

How does perceived team psychological safety shape teachers' willingness to engage in professional learning activities?

Data Analysis Procedures

Data analysis focused on identifying interpersonal actions that involve professional risk-taking, including speaking up, expressing uncertainty, engaging in reflective questioning, experimentation, and feedback-seeking. Relevant excerpts were drawn from teacher leaders' professional learning activities in which participants described how the professional learning experience influenced their thinking, behaviors, and engagement.

Analysis proceeded through a hybrid deductive–inductive coding process. Deductively, an initial coding framework was informed by Frazier et al.'s (2017) model of psychological safety antecedents and Edmondson's (1999) conceptualization of learning behaviors as observable indicators of interpersonal risk-taking in learning contexts. Inductively, codes were refined and expanded through close reading of the data to capture emergent patterns, language, and meanings specific to the teacher leadership context. This iterative process allowed the analysis to remain theoretically grounded while also responsive to participants' experiences within the professional learning environment.

Summary of Findings

Preliminary analysis indicates the emergence of patterned shifts in how individual team members engage in interpersonal risk. Full thematic findings will be discussed at the time of the conference, including illustrative excerpts and analytic memos. Across the professional learning activities, participants described engaging in these learning behaviors in ways they explicitly linked to the psychologically safe environment provided by the LEADS program.

Participants reported feeling respected, unjudged, and valued, which reduced fear of negative evaluation and increased their willingness to take interpersonal risks necessary for learning.

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Mentorship as a Catalyst for Faculty Adoption of Active Learning in Mathematics

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Background and Significance

Active learning consistently improves student achievement in STEM courses, raising exam performance and lowering failure rates compared with lecture-based instruction (Freeman et al., 2014). Yet, many instructors who complete professional development continue to lecture more than they realize (Ebert-May et al., 2011). This gap between knowledge and practice highlights the need for faculty development that is ongoing, reflective, and rooted in real classroom contexts (Gyurko et al., 2016).

Mentorship offers such a model. When mentors and mentees engage in co-learning, reflection, and feedback, mentoring grounded in constructivist principles enhances teacher efficacy and enthusiasm while reducing burnout (Richter et al., 2013). In mathematics, mentoring is most effective when aligned with instructors' specific content and pedagogical needs (Nel & Luneta, 2017). Research also cautions that mentoring can falter when mentors lack sufficient mathematical expertise, reinforcing the value of discipline-matched mentoring (Masina & Mbokazi, 2023).

The *Successful Engagement: Active Learning in Mathematics* (SEAL-M) project addresses these needs through a sustained faculty development program for mathematics instructors at a large, multi-campus Hispanic-Serving Institution. Funded by the National Science Foundation (IUSE EHR #2111262), SEAL-M combines a Summer Institute, Mentor Training, and a year-long Mentorship Program to strengthen active learning implementation while examining faculty beliefs, perceived barriers, and teaching practices. Research Questions

1. To what extent does a mathematics faculty development program consisting of a Summer Institute, Mentor Training, and a Mentorship Program influence growthmindset belief and mitigate perceived barriers to active learning implementation at a large, two-year Hispanic-Serving Institution?

2. Is there a correlational relationship between faculty knowledge and attitudes toward inclusive teaching practices and active learning implementation in a mathematics setting?

Methods and Data Analysis

This mixed-methods study draws on four years of SEAL-M data from more than 60 mathematics faculty. Data sources include pre- and post-program surveys measuring mindset beliefs, knowledge, and perceived barriers; weekly mentee reflections describing instructional experiences; and focus groups with mentors, mentees, and project leaders.

Quantitative data were analyzed using paired t-tests and correlation analyses to examine relationships among mindset, inclusive-teaching attitudes, and implementation behaviors.

Qualitative data underwent inductive thematic coding to identify changes in perceptions, implementation patterns, and contextual barriers.

Findings

Participants reported increased confidence using active learning strategies, a clearer understanding of how to design engaging mathematics lessons, and stronger motivation to sustain new approaches. Mentorship was described as a key support structure, enabling feedback, collaboration, and shared problem-solving.

Persistent barriers included limited time, varied student preparation, and challenges adapting active learning to online or hybrid courses. Instructors found asynchronous formats particularly difficult for fostering collaboration and accountability. Quantitative analyses suggested a positive relationship between faculty attitudes aligned with inclusive teaching practices and their use of active learning. Faculty demonstrating stronger growth mindset beliefs also perceived fewer obstacles to student-centered instruction.

Discussion and Implications

SEAL-M demonstrates how relationship-based, discipline-specific professional learning can shape both instructional beliefs and teaching practice. Mentorship and sustained reflection appear to narrow the gap between theory and classroom implementation. Nonetheless, the continued difficulty of applying active learning in digital environments underscores the need for new strategies to support online engagement and mentor preparation.

Future work will incorporate classroom observation data to examine links among mindset, pedagogical beliefs, and observable teaching practices. Overall, SEAL-M highlights mentorship as a practical, scalable approach for helping mathematics faculty translate professional development into durable instructional change.

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NSF S-STEM: Diversity and Excellence in Food, Environment and Natural Resource Disciplines (DEFEND) at Alabama A&M University

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Abstract

This project contributes to the national need for well-educated scientists, mathematicians, engineers, and technicians by supporting the retention and graduation of high-achieving, low-income students with demonstrated financial need at Alabama A&M University. Alabama A&M University is a Historically Black College and University (HBCU) located in Huntsville, AL. In the four years since its inception, this project has funded 19 scholarships to full-time students who are pursuing bachelor's degrees in food science, environmental science and natural resource disciplines. The project aims were to increase student persistence in STEM fields by linking scholarships with effective supporting activities, including mentoring, service learning (academic advising, tutorial assistance, financial counseling), undergraduate research experiences, outreach and volunteer projects, graduate school preparation, and participation in discipline-specific conferences. The project also supported curriculum improvements aimed at improving first-year student retention in STEM. Because Alabama A&M University has a high population of underrepresented students, this project has the potential to broaden participation in STEM fields and to understand how impactful mentoring and individual development plans support retention and graduation of this student population.

The overall goal of this project was to increase STEM degree completion of low-income, high achieving undergraduates with demonstrated financial need. Specifically, this project was designed to increase the recruitment, retention and student success of students in agricultural and life sciences (environmental science, animal bio-health, forestry and food science). There are three specific aims: To Increase degree attainment by low-income students enrolled in BS programs within the College of Agricultural and Natural Sciences (CALNS); Offer curricular and cocurricular activities to increase student success by engaging them in specific tested and evidence-based enrichment activities; and Use Technology for Intentional Student Evaluation and Program Assessment. Over half of underrepresented minorities provide two main reasons for leaving without completing a degree or certificate: *financial reasons* and *family responsibilities.* Additionally, a small percentage of low-income students transfer to four-year institutions compared to their most advantaged peers within this time frame. The intervention outlined here combines financial resources with rigorous mentoring and tutorial support to thwart attrition throughout the degree program and compare relative effectiveness of post-high school summer support and tuition support among students transferring from community colleges in motivating and retaining African American students. To help fill the gap, this project addresses the issue of the "Summer Melt" of recent high school graduates and compares the overall success rate (retention and graduation rates, job placement, graduate school) of high school students directly entering AAMU vs. community college transfers and also compares the success rate of

these DEFEND scholars with other students within CALNS. The scope of this project will generate new knowledge and excellence resolving inquiries into if students that attend four years at the same institution have greater success than those that transfer from other community colleges, if/how sustained financial aid assists in reduction of borrowing among students, what will be the success rate (*GPA, retention and graduation rates, job placement/graduate school*) of low-income undergraduate and identified as DEFEND scholars compared to students with the same selected majors from rest of the state who are not DEFEND scholars and thus will serve as our control group, how will the Summer Melt Program affect the success rate of the DEFEND scholars vs. control group, and will the increased communication with faculty and peers result in higher retention/graduation rates. Data will be gathered about student engagement, performance, retention, and characteristics such as changes in science identity and self-efficacy. This project has the potential to advance understanding of which interventions are most effective for motivating and retaining African American and underrepresented students, specifically those entering AAMU through the "Summer Melt" program and those transferring to AAMU from a community college. Additionally, this project would increase the number of underrepresented students who are globally and competitively trained and subsequently diversify the STEM workforce. Evaluation was continuous to assess student and mentor needs, goals and experiences, as well as determine measurable goals and learning outcomes through scholars' academic and co-curricular evaluations. Data was gathered regarding student engagement, performance, retention, and motivational strategies for continued educational success among all but especially underrepresented communities and widely shared with students, parents, educators and education and S&E policy makers. This project is funded by NSF's Scholarships in Science, Technology, Engineering, and Mathematics program, which seeks to increase the number of low-income academically talented students with demonstrated financial need who earn degrees in STEM fields. It also aims to improve the education of future STEM workers, and to generate knowledge about academic success, retention, transfer, graduation, and academic/career pathways of low-income students.

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Predicting High School Graduation Rate Using Clustered Multilevel Modeling

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Abstract: The study investigated the predictive variables at level-1 and level-2 that impact the prediction of high school graduation rate—the outcome variable—in the U.S. state of Tennessee and its impact on STEM career choices. Multilevel models were fitted to 241 schools nested in 81 school districts to examine within-district school-level effects of student cohort population and student absenteeism, as well as contextual-district effects of staff count and district classification (urban or rural). Results show that within district student cohort population and student absenteeism and contextual-district staff count, and district classification are good predictive variables of high school students' graduation rate.

Background literature and Problem Statement

Graduation rate is one of the strongest indicators of educational or academic success across the globe, particularly in the United States (Ring, 2017). In the U.S., graduation rate in K-12 educational settings is tied to the performance of school districts and continues to be used for gauging academic success and/or rank high schools (HS) across the board (Millea et al., 2018). While myriad metrics serve as indicators of academic and/or educational success across K-12 school districts in the U.S., graduation rate stands out as one of the pertinent indicators of academic success at the high school level (Lewis, 1996; Marshall, 2022; Pinkus, 2008). One school of thought on graduation rate has argued that a huge gap exists in HS graduation rate between rural school and urban schools. While this statement is arguably contentious, it serves as a starting point to adopt significant predictive models to examine HS graduation rate in the state of Tennessee in the U.S.

Particularly important is that extant literature on graduation rate either utilized hierarchical general linear models (Subedi & Howard, 2013; Subedi & Howard, 2017) or simple linear regression models (Ritter, 2015; Silver et al., 2008; Soland, 2013; Zaff et al., 2017) to predict their outcome variable. A dire need therefore exists to predict high school graduation rate using clustered multilevel models that can account for within-district school-level effects and contextual-district effects of all predictors (Holodinsky et al., 2020). This study specifically draws on the strength of level-1 predictors at the school level and level2 predictors at the district level to predict student graduation rate across schools and districts in the state of Tennessee.

Identifying the significance of level-1 predictors in predicting outcome variables in earlier studies (Holodinsky et al., 2020; Moral-Benito, 2015), the study sought to predict high school graduation in the state of Tennessee, examining the impact of variations in level-1 cohort population and chronic absenteeism in predicting high school graduation. This study, again, draws on the strengths of model-based designs to predict high school graduation rate in the state of Tennessee in the U.S. using school level-1 predictor variables—school cohort population and student absenteeism data.

The graduation rate data in the state of Tennessee was fitting, as it allowed for using level-1 predictors (chronic school absenteeism and graduating cohort populations) to predict the individual school characteristics, while simultaneously drawing on level-2 district staff count and district classification characterization to predict contextual-district effects on graduation rate. Thus, chronic absenteeism and school cohort population would allow for the evaluation of the school-level chronic absenteeism and cohort population in the context of their reductions in variance through their regression coefficients. The impact of contextual effects was also examined using district staff count and district characterization (urban or rural).

Purpose of the Study: The primary purpose of this study was to specifically utilize multilevel models to account for *within* and *contextual* effects of all predictors, at level-1 and level-2, respectively. This allowed for a better prediction, particularly within the context of out-sampled data, relative to single-level linear regression (Moral-Benito, 2015).

Significance of the study: Findings from this study argue for and redound the significant effects of student absenteeism and school population to HS students' graduation in the state of Tennessee and on higher education STEM contexts. Again, the study would help Tennessee's K12 schools and districts to identify the predictive variables of HS graduation, providing affordance to implement targeted interventions for at-risk students.

Research Questions: Two research questions were posed to guide the study.

1. What school-level variables are predictive of school differences in graduation rates?
2. What district-level variables are predictive of district differences in graduation rates?

Methods—Study Design and Data Sources

A two-level model design was employed to predict our outcome variable, graduation rate, using two school-level (level-1)—chronic student absenteeism and cohort population of school—and two additional district level (District (instructional) staff count and Classification of the Districts, Urban or Rural) predictors. 241 schools at level-1 were nested into 81 districts at level-2 from the Department of Education in Tennessee data.

Data Analysis Procedures

LMER within the LME4 R package was utilized to estimate fixed effects for the intercept and slopes, as well as the variance components for the remaining random and residual effects after controlling for the fixed effects of level-1 (school) and level-2 (district) predictors.

The categorical variable regarding whether a district is urban (metro) or rural (micro) was dummy coded. If the district was urban categorized, it was coded as 0 and if it was rural categorized, it was coded as 1. Regarding centering, the level-1 predictor for student absenteeism was centered at 20, as was its level2 district mean. The level-1 predictor for cohort population was rescaled by dividing by 100 and then centered so that the reference school contained 300 students on average. The level-2 district mean was also centered at 300 students. This method of constant-centering of level-1 predictors while including their district means created within-district and contextual-district fixed effects, respectively. District averaged staff count and

population as level-2 predictors were first rescaled by dividing by 1,000 and 10,000, and they were then centered at their sample means.

The extent to which high school graduation outcome (M = 88.48, SD = 10.60, range = 9.00 to 98.70) could be predicted from school-level variables of students' chronic absenteeism and cohort population was investigated in a series of multilevel models in which 241 schools were modeled as nested within their 81 districts in the state of Tennessee. Restricted maximum likelihood (REML) within R lmer was utilized to estimate and report all model parameters. While the significance of fixed effects was evaluated with univariate Wald tests using Satterthwaite denominator degrees of freedom, random effects were evaluated via likelihood ratio tests (i.e., $-2\Delta LL$ with degrees of freedom equal to the number of new random effects variances). Alpha was chosen as .05. Effect size for the fixed effects was evaluated through pseudo-R^2 values for the proportion reduction in each variance component relative to a nested model without the predictors in question.

A model with all level-1 and level-2 fixed effects of interest was then estimated, including the effects of school-level predictors of cohort population (per 100 students, centered so that the intercept refers to 300 student cohorts in a school) and student absenteeism (centered so that the intercept refers to 20 average days of absence) as well as district-level means for cohort population and student absenteeism, staff instructional count, and urban/rural district classification. The fixed slopes of our level-2 predictors accounted for 93.5% of our district-level random intercept variance and 11.3% of school-level residual variance.

Summary Findings/Discussion

An initial unadjusted intraclass correlations (ICC) revealed that district mean differences accounted for about 14% of variance in high school graduation rate. This is suggestive of clustering evidence in our data, consistent with the choice of multilevel modeling to examine our data (Hox et al., 2017). Almost 14% of the proportion of total variance was between districts, expressing cluster dependency within the dataset for the study (Talavera, 2000). This is consistent with the extant multilevel modeling literature, which also underscored the significance and/or necessity of adding more models to the null model (Patrick, 2001; Uretsky, 2019)

First, research question 1 sought to investigate the school-level variables that are predictive of school differences in graduation rates, examining within-district school-level effects. Results show that the addition of level-1 variables in our model helped to explain about 11.31% of the school-level residual variance. Results show that a change in cohort population per 100 students non-significantly impacted student graduation outcomes. In addition, results showed that for more average days of absence, there was a corresponding significantly negative impact on student graduation outcomes.

Research question 2 also sought to examine the district-level variables that are predictive of district differences in graduation rates, including contextual-district effects. Results show that the addition of level2 variables in our model helped to explain about 76.44% of the district-level random intercept variance. District staff count showed that an increase in staff count predicted lower graduation rate outcomes for students. Further results show that the incremental effect of

district staff count after controlling for the school-level effects—the between-district effect was significantly predictive of student graduation rate outcomes in the state of Tennessee. Thus, on average, the higher the staff count, the lower the rate of HS graduation in the state of Tennessee. There remained significant variability in the average graduation rate across groups (Intercept variance = 0.8901) and urban and rural schools.

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Project-Based Learning in Aerodynamics:
A Case Study on PBL as a Predictor of Student Success

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Project-Based Learning (PBL) is an educational approach that promotes active engagement and practical application of theoretical concepts. In STEM classrooms, such as aviation, PBL fosters critical thinking, problem-solving, and collaborative skills, aligning closely with real-world or industry challenges. This study explores the effectiveness of PBL in enhancing student outcomes within a college-level aerodynamics course through a hands-on glider-building project. The project aimed to determine if glider performance, measured by distance flown, could serve as a reliable predictor of final exam scores and overall course performance.

To assess the impact of PBL on student learning, a pre-test/post-test method was utilized to test student's knowledge before and after building the glider. Before beginning the project, Students were given a pre-test to evaluate their foundational knowledge of aerodynamics and glider construction. After completing the project, a post-test will be administered. Students' glider distances will then be compared to both the pre-test and post-test results, as well as final exam scores, to examine potential correlations between project success and academic performance.

This study hypothesizes that the hands-on experience of constructing and testing gliders will result in improved post-test scores and that glider performance may indicate broader conceptual understanding, thereby predicting higher final exam scores. The findings could have implications for the integration of PBL strategies in aviation and other STEM disciplines to enhance student engagement and academic achievement.

Questioning Selves, Questioning Minds:
Women's Persistence in Doctoral Programs

Holly Anthony & Martha Howard
(Tennessee Tech University)

This qualitative interview study was focused on 13 women (representative of 8 Ph.D. programs, 7 universities, and 5 States) who identified themselves as having questioned their continuation in a doctoral program (due to self-doubts), but who successfully completed the program and now use their degree in their career. The purpose of this project was to understand their doctoral experiences and how they persisted. Research questions included: (1) What kinds of experiences lead women doctoral students to question themselves and their abilities? (2) What motivates women to persist in doctoral programs? How do they persist? Inductive analysis of interview transcripts revealed that Ph.D. programs that seek to improve the retention of women should consider (1) being proactive in cohort development, (2) designing social activities to keep students "connected," (3) think carefully about advisor/advisee "matching," and (4) acknowledge that the doctoral journey for women differs from that of their male peers.

Student Perceptions of Learning Gains in Revised General Education Science Course

Tamera Klingbyll
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Introduction

The purpose of the study was to improve instructional techniques in the general education biology course at Lipscomb University in Nashville, Tennessee. This study represents an extension from graduate research which focused on general education sciences, including biology. Lipscomb University requires a science course with a lab as part of the general education core. The study of science consists of content and inquiry. While some post-secondary schools may require a general education core of courses, the choice of when and how those courses are taken remains up to each student (Seaver College Academic Catalog - Pepperdine, 2020). The core of courses generally consists of the liberal arts and sciences. Using the general education requirement for a science course with a lab as a focal point, the instructional teaching strategies utilized were assessed.

Significance

The Association of American Colleges & Universities (AAC&U) published a report noting the need for skills in business that are gained while in a college with a liberal arts education background (Finley, 2021). Finley (2021) reported the findings of the AAC&U employer survey. Skill areas, considered very important by over 50% of the respondents, included the ability to think critically, apply knowledge to real-world situations, complex problem-solving, and the ability to process data (Finley, 2021). Since liberal arts higher education can produce the required skills for future employees, the question becomes which of the liberal arts courses can produce the required skills (Rudolph, 2020). These same skills are a factor in the Next Generation Science Standards (NGSS Lead States, 2013, Rudolph, 2020).

The significance of scaffolding began with the works of Dewey, Piaget, and Vygotsky, noting that learning begins early in life and as it continues, learning experiences create scaffolds (Gutek, 2011; Bächtold, 2013; Breunig, 2017; McLeod, 2018). Ignatius Loyola (1548) promoted this stance, which later developed into universal instructional design (UID). UID encourages students to learn, reflect, and act upon life experiences (Pousson & Myers, 2018). Students are taught similar information throughout their academic years, but each time the information is taught, the depth of the information increases. Some universities within the United States, a core of general education classes continues the tradition of the liberal arts and sciences belief of preparing students with a grounding in university thought, the ability to function well in society (Undergraduate Catalog – University of Alabama, 2020; Harvard University Course Catalog,

2020; 2020-2021 Undergraduate Catalog- Lipscomb University, 2020; Seaver College Academic Catalog - Pepperdine, 2020). Aristotle used the sciences in conjunction with the liberal arts to

increase knowledge (Gutek, 2011). As content changes within the sciences, so do the technologies used for their presentation. The art of instruction once relied upon the gathering of students at a single location, who were similar in age and world experience with similar gains in technology. Changes within the technological world now provide university classrooms with students varying in age, world, and technological experience, and classrooms which occur via differing locations at different times.

Research question

"How can students' learning general education biology perceptions be improved at Lipscomb university?"

Methodology and Timeline

A convenience sample of participants came from a variety of major backgrounds, excluding the sciences, and a variety of academic status (freshman, sophomore, junior, or senior). The original study took place during the fall of 2022. Based upon the data collected, the course was restructured, and a more direct SALG was developed, using the original survey as a starting point. A modified SALG with responses pertaining to learning gains provided the questionnaire quantity (Seymour, Wiese, Hunter, & Daffinrud, 2000). The SALG also provided spaces for question elaboration and possible improvement on strategy design. Data collection via a mixed survey was done, during the last two weeks of fall and spring semesters 2023-24.

Students within the class were asked if they would like to participate.

Interested students signed a consent form. Students were informed that open-ended replies would not be viewed until grades were posted. This ensured that unique writing styles would not create any bias. Students were reassured that they could opt out any time without any problems. Those signing a consent form were sent an email invitation from the survey site REDcap (Harris, Taylor, Thielke, Payne, Gonzalez, & Conde, 2009; Harris, Taylor, Minor, Elliott, Fernandez,

O'Neal, McLeod, Delacqua, Delacqua, Kirby, & Duda, 2019). Likert data was analyzed via EXCEL looking at standard deviation and mean. Open ended questions were gathered, then replies read, and categories coded (Cresswell & Poth, 2018).

Implementation

From the Fall 2022 collected research data, the general education biology class was restructured. Students took a pre-quiz to reveal their basic knowledge. The revised course was placed into quadrants of ecological and biological information, concluding with a summative quiz for each quadrant. As an example, quadrant one reviewed municipal wastes locally and globally and its effects on water quality, the life which the water sustains and the possible effects upon the human endocrine system. Learning strategies mixed throughout each quadrant included

discussion (pair to class), modeling, traditional lecture, films, cooperative learning, reading, and reflection assignments. Labs were used to help tie concepts together. Response rate was 21%. During the spring semester discussion and cooperative learning were lessened due to unexpected snow days; feedback from the students reflected the removal. Response rate was 20%. More cooperative learning took place during the fall and spring 2024-25 semesters based upon the spring 2024 data. Final group presentations replaced final exams for the course in spring 2025. Response rates from students have remained consistent with 37% for fall 2024 and 25% for spring 2025.

Lipscomb University is modifying the General Education core, the Foundations course will be phased out. IRB has approved this year's data collection. New findings will help guide a new study for a freshman level Biology major's lab. As varied as the majors and times when courses are taken are the ways in which students learn. The major effect seen in restructuring by using a multimodal delivery of relevant information is students more interested in science (GAP Technologies, 2022).

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Students' Perceptions and Awareness of the Cultural Differences Between Physical Chemistry and its Prerequisites

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Study Background and Research Significance

Physical chemistry is an upper-level undergraduate course that explores the interface of chemistry and physics using calculus. Success in this course relies on activating and integrating knowledge from multiple domains, including the introductory calculus and physics sequences. These courses exist within multiple departments which can use different language to describe the same phenomena (Rabin et al., 2021). Previous research on physics and mathematics double majors identified that these students were aware of cultural differences between their physics and mathematics courses, as well as distinct physics pedagogical practices that hindered their ability to activate their previous mathematical knowledge in physical contexts (Rabin et al., 2024). This case study, while focused in its study population, brings attention to students' experiences navigating multidisciplinary contexts. Since physical chemistry also sits at the interface of multiple disciplinary domains of knowledge, we are interested in whether students enrolled in physical chemistry were also aware of any cultural differences in the course and its prerequisites.

This work is grounded in conceptual integration (Coulson & Oakley, 2001; Fauconnier & Turner, 2008) and conceptual integration which posits that knowledge from multiple domains must be successfully integrated to achieve a new, blended understanding. This framework has been used previously to understand the cognitive processes used in chemical kinetics (Bain et al., 2018). In this context, we are interested in the perceived barriers to successful conceptual integration.

Research Questions

1. Are undergraduate physical chemistry students aware of cultural differences between chemistry, mathematics, and physics in the presentation of mathematical content in different contexts?
2. How do they perceive these differences in impacting their learning and ability to succeed in physical chemistry?
3. Overall, how do they view their curricular progression leading up to physical chemistry?

Methods
Undergraduate students currently enrolled in physical chemistry were invited to participate in a survey. The survey was based on previous work on physics and mathematics double majors (Rabin et al., 2024) and was adapted to elicit recollections of conceptual integration (Bain et al., 2019) between chemistry, physics, and mathematics. Students were also invited to take part in a semi- structured interview based on their survey responses.

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Supplementing Aviation Maintenance Curriculum with VR

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Aviation Maintenance Technician Schools (AMTS) play a major role in meeting the growing demand for aviation technicians. In 2023, two-thirds of all new mechanics were graduates of one of 200 AMTS (ATEC, 2024). An overwhelming majority of mechanics will work for repair stations or air carriers (ATEC, 2024), which raises an interesting challenge for aviation maintenance training.

Most of the maintenance training conducted at the collegiate level (2-year and 4-year programs) focus heavily on General Aviation (GA) rather than transport category aircraft. However, a significant amount of maintenance school graduates will work on transport category aircraft, which is the type of aircraft used by airlines. The reason students are trained on GA aircraft and equipment is because GA equipment is much cheaper to acquire. Consider the cost of acquiring a four-seat propeller-driven aircraft versus a turbine-engine driven 70-seat regional aircraft.

Additionally, due to financial constraints of most AMTS, training aids, technology, and equipment at AMTS are not as advanced as what its students will see in the industry. For example, it is very difficult for an AMTS to provide students with exposure to advanced transport category aircraft systems beyond theoretical lectures, pictures, and diagrams. However, incorporating virtual reality (VR) in an AMTS curriculum could provide students with an enhanced understanding of advanced aircraft systems. Studies indicate that using immersive technologies resulted in improved knowledge retention in aviation maintenance training (Fussell & Truong, 2023). Additionally, using immersive technology in aviation training has shown to improve safety and reduce training costs (Birdsong & Reesman, 2024).

In our study, participants from a collegiate AMTS used VR in conjunction with classroom instruction and lab activities. We have collected preliminary data in implementing VR in an advanced systems course, and we are using the feedback to design and improve future classroom activities with VR. We will discuss our experience with VR, feedback from students and instructors, and lessons learned.

Teaching Scientists to Communicate: Exploring the Literature on Science Communication Training

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Background:
Effective science communication is crucial not only for professional scientists but also for students at all levels (Brownell et al., 2013). In fact, scholars have identified science communication as a key skill for all undergraduate science students (AAAS, 2009). While research has highlighted key priorities for science communication training (Baram-Tsabari & Lewenstein, 2017; Besley et al., 2016), there's been little effort to synthesize existing work. This lack of synthesis makes it challenging to identify successful programs, establish best practices, and pinpoint areas for further research.

Even though effective science communication is crucial for students at all levels, undergraduate students are rarely trained in science communication. This might be surprising as undergraduate students have been shown to already communicate about science with the public, even before graduation (Shah et al., 2022). However, undergraduate students often use ineffective strategies when communicating science, likely due to the lack of formal training they receive (Shah et al., 2022). To help science educators train their students in science communication, we designed a systematic literature review that identifies best practices in science communication education.

Research Questions:
RQ1: What is the volume of published science communication education research, and how much centers on undergraduates?
RQ2: What are the main foci of primary research in science communication education?
RQ3: How often do studies report validity evidence for their methods and measures?
RQ4: To what extent do science education and communication researchers collaborate?

Data Analysis:
The goal of this study is to provide a broad overview of the science communication training literature, focusing on trends and gaps. We created a coding system to categorize articles by publication type (primary research vs. reviews), type of communication (audience, scientific, or interpersonal), the format of the training, the discipline, and whether the training was evaluated for efficacy.

A second section of the coding system exists to categorize articles that were evaluated for efficacy. Articles with quantitative data were categorized by data collected, constructs measured (e.g. competence, confidence), whether the survey was novel or preexisting, whether the survey presented validity evidence (e.g. structural, content), and whether the survey was available to the public. Articles with qualitative data were categorized by data collected, type of qualitative analysis, and reliability evidence (e.g. multiple coders, inter-rater reliability).

Articles with no available data were not coded for methods.

Findings:
So far, we have identified 350 unique articles and coded 175 of them. Of all science communication training articles that have been published in the last 20 years, very few trains undergraduate students. The relatively low amount of undergraduate-focused training points to a gap in providing students with the communication skills needed in their future careers. However, there has been a steady increase in the volume of published undergraduate science communication training articles in the last 20 years. Of the coded articles, 54% focus on training students in communicating to non-scientific audiences, 27% focus on training students in communicating to scientific audiences. Very few of the articles focus on training students in interpersonal communication. Further, even fewer articles focus on the training of interpersonal communication of controversial science topics. A large proportion of quantitative studies include measures of self-efficacy and value, while only 10% of articles include measures of science identity. Almost half of qualitative and quantitative articles do not describe the development or validity evidence for their methods and measures. Additionally, there are many isolated authorship groups within the undergraduate science communication literature and very few collaborations include communication scholars.

Significance:
Although these data are preliminary, they suggest that there is not enough primary research being published to share evidence-based training practices with educators seeking to implement science communication training. However, instructors and researchers can mold this growing field by publishing their science communication education research. These data also suggest that more research needs to be done on implementing training for undergraduate students and on interpersonal communication, particularly since undergraduate students are already actively having scientific discussions with members of their communities (Couch et al., 2022; Shah et al., 2022). Finally, these data suggest that researchers should include validity and trustworthiness evidence to support the field's credibility.

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Technology-Enhanced Preparation for Global Learning: Evaluation of a Uruguay Study Abroad Pre-Departure Curriculum

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Background Research

Global education prepares students to navigate increasingly interconnected contexts by building academic, professional, and intercultural competencies (Fong, 2020). Study abroad programs are a key vehicle for this development, helping students analyze global issues, collaborate across cultures, and adapt to diverse environments. These experiences also strengthen critical thinking, communication, and problem-solving skills central to science, technology, engineering, and mathematics (STEM) education. To support these outcomes, many institutions now incorporate technology-enhanced pre-departure training, delivered through online modules, interactive case studies, and multimedia resources (Boyington et al., 2025). Digital tools offer flexibility and engagement, allowing students to explore context-specific content while practicing cross-cultural communication. Research indicates that such technology-mediated learning enhances intercultural competence (Cutting et al., 2022; Goldstein, 2022), supports STEM-related problem solving through authentic, applied contexts (Kalbarczyk et al., 2019), and reduces risks abroad (Kosman et al., 2023). Yet few studies examine how students experience these digital curricula in short-term, agriculture-focused programs where applied science and cultural learning intersect. Addressing this gap, the present study evaluates a technology-enhanced pre-departure curriculum designed for a one-week study abroad program in Uruguay, integrating agricultural science, cultural intelligence, and digital learning to prepare students for global engagement.

Significance of Research

Integrating technology into pre-departure training enhances opportunities for experiential learning in STEM and agricultural education. Digital modules, virtual case studies, and multimedia content allow students to apply scientific reasoning and intercultural understanding before entering global contexts. In agricultural education, these tools can connect technical and cultural dimensions of learning, helping students engage more deeply with global sustainability and systems thinking. Existing research shows that educational technologies increase engagement, critical thinking, and the transfer of scientific knowledge in agricultural education (Xu et al., 2023). Similarly, systematic reviews of pre-departure training emphasize that interactive, context-specific, and technology-mediated learning environments improve competence and self-efficacy for global experiences (Kalbarczyk et al., 2019). By examining how students perceive a technology-enhanced pre-departure curriculum in an agriculture-based study abroad program, this study contributes to growing research on how digital innovation supports STEM learning and intercultural readiness.

Methodology

An anonymous Qualtrics survey was administered to undergraduates (N = 11) participating in a one-week study abroad program following 8 weeks of pre-departure modules (March 2025). The 12-item instrument included Likert-scale ratings, engagement rankings, and open-ended prompts. Developed with faculty input and informed by intercultural learning literature, the instrument was reviewed for content validity. Quantitative data were analyzed descriptively in SPSS, and qualitative responses were thematically coded. Limitations include a small, single-institution sample, reliance on self-report data (potentially leading to response bias), missing items, and the use of descriptive rather than inferential statistics. Findings are exploratory and context-specific.

Results / Findings

Quantitative results showed high perceived effectiveness across modules (M = 4.00–4.64 on a 1–5 scale). Land Grant & INIA and Cultural Intelligence & Things to Expect scored highest (M = 4.64 each), while Forage Management scored lowest (M = 4.00). Engagement rankings highlighted the U.S. Beef Supply Chain (82%) and Cultural Intelligence modules (73%) as most engaging. Overall satisfaction with preparation was high (M = 4.70, SD = 0.48).

Qualitative themes included:

1. Adequacy of preparation – students felt well-prepared overall, describing the modules as comprehensive and confidence-building.
2. Need for language and culture-focused content – students desired introductory Spanish and clearer expectations for cultural norms.
3. Preferences for engagement and delivery – students preferred shorter, segmented modules, reflective assessments, and interactive activities.
4. Targeted improvements – students recommended Uruguay-specific case studies, alumni voices, practical readiness tools (translation apps, packing guidance), and visuals from past trips.

Conclusions

Students perceived the curriculum as effective overall, especially modules that were both destination-specific and interactive. However, gaps included limited Spanish preparation, static delivery, and insufficient applied content. Addressing these issues can strengthen intercultural competence, reduce stress during transition abroad, and enhance engagement with host communities. These findings align with Bandura's (1997) view that increasing students' confidence in their skills supports effective performance in challenging contexts.

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