S²ERC

SOUTHEASTERN STEM EDUCATION RESEARCH CONFERENCE

2025

JANUARY 10-11, 2025

HOSTED BY

THE UNIVERSITY OF ALABAMA AT BIRMINGHAM

Birmingham, Alabama

19th Annual Southeastern STEM Education Research Conference

January 10-11, 2025

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Tennessee STEM
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EVENT HOST AND SPONSOR

UAB CAMPUS/ PARKING MAP

ORAL & POSTER SESSIONS AND EARLY CAREER PANEL WILL TAKE PLACE IN HERITAGE HALL
DINNER AND KEYNOTE WILL BE HELD AT ALUMNI HOUSE

- **PARKING AVAILABLE IN 12TH STREET PARKING GARAGE**
- **STREET PARKING ALSO AVAILABLE (FREE AFTER 5PM)**
- **LIMITED PARKING SPACES AVAILABLE IN ALUMNI HOUSE PARKING LOT**

19th Annual Southeastern STEM Education Research Conference

January 10-11, 2025

Friday, January 10

12:00 pm **Registration Opens – Heritage Hall Lobby**

12:00 pm – 4:30 pm **Poster Session Setup – Heritage Hall Lobby**

1:30 pm – 3:00 pm **Early Career Panel – Heritage Hall, Room 104**

2:00 pm – 4:00 pm **Refreshments – Heritage Hall Lobby**

3:30 pm – 5:00 pm **Parallel Oral Sessions (Sessions 1 and 2) – Heritage Hall**

Oral Presentations – Session 1 (STEM Education)
Heritage Hall, Room 104 Facilitator: Dr. Brenna Tucker

3:30 pm **Introductory Remarks**
3:35 pm **An Examination of the Efficacy of an Aerospace Living Learning Community,** *Timothy Rosser (Middle Tennessee State University)*
3:55 pm **Specifications Grading in Data Science Education: Implementation and Evaluation of Proposed Student Outcomes,** *Brandon Yik (University of Georgia), Loreto P. Alonzi III, Brian M. Wright, & Marilyne Stains (University of Virginia)*
4:15 pm **Increasing Success and Retention of Female Students in Computer Science by Enhancing Two Key Factors: Math Proficiency and Programming Skills,** *Yi Gu, Jaishree Ranganathan, & Lu Xiong (Middle Tennessee State University)*
4:35 pm **Experimental Measurement and Establishment of Communication Metrics Using a Highly Interactive and Visually Enhance Robot Platform,** *Samina Upama & Bruce Jo (Tennessee Tech University)*

Oral Presentations – Session 2 (STEM Education)
Heritage Hall, Room 121 Facilitator: Dr. Daniel Siao

3:30 pm **Introductory Remarks**
3:35 pm **Exploring How Low-Income Students Navigate Inequities in Undergraduate Research Experiences,** *Emma Goodwin (University of Georgia), Sailor Dereadt, Jasmine Goode, Bec Kalfus, Gailan Khanania, Laura Pang, & Sara Brownell (Arizona State University)*
3:55 pm **Complex Systems, Emergence, and Conceptualizations of Learning,** *Jonan Donaldson, (University of Alabama at Birmingham)*

4:15 pm **STEMMing the Tide: Empowering Youth to Meet Coastal Environmental Challenges,** *Kate Hayden (University of Montevallo), Vincent T. Gawronksli (Birmingham-Southern College), Ronald Hazelhoff & Mark Meade (University of Alabama at Birmingham), Desiree' Melonas (University of California, Riverside), Danielle Haskett-Jennings (University of Montevallo), Kelly Russell (Troy University), Louanne Jacobs (i3Academy)*

4:35 pm **Science Identity Development of First-Generation College Students in Two Learning Assistant-Supported Classrooms,** *Kathryn Hosbein, Oluwatobiloba Ayangbola, & Sarah Bleiler-Baxter (Middle Tennessee State University)*

5:00-6:00 pm - Poster Session – Heritage Hall Lobby

1. **An Exploration of Thwarted Belongingness and Perceived Burdensomeness Among Undergraduate Agriculture Student,** *Carly Altman & Chaney Mosley (Middle Tennessee State University)*
2. **Catalyzing Departmental Change: A Literature Review of Barriers, Drivers, and Framing,** *Cassandra Mohr, Cory Wang, Sarah Bleiler-Baxter, Mary E. Foley, Alyssa S. Freeman, Aspen Malone, Andrew R. Puente, Grant E. Gardner, & Gregory T. Rushton, (Middle Tennessee State University)*
3. **Chemistry Bridge: An Outreach Program for Incoming High Schoolers,** *Corey Burns, Tyrese J. Boddie, Riley P. Cooper, Zachary B. Dotson, & Anna L. Wong, (University of Alabama at Birmingham)*
4. **CURE Inception: Teaching Undergraduate Biology Students Science Communication About Culturally Controversial Topics by Having Them Research How Undergraduates Currently Communicate About Culturally Controversial Topics,** *Mary Foley & Elizabeth Barns (Middle Tennessee State University)*
5. **Developing Data Science Through Community Engagement: MVP Model,** *Juan Carlos Gonzalez-Roman & Lynn Hodge (University of Tennessee, Knoxville)*
6. **Developing Instruments to Evaluate and Improve Undergraduate Interpersonal Science Communication About Culturally Controversial Science Topics,** *Erin Rowland-Schaefer, Kate Coscia, Donye Asberry, & M. Elizabeth Barnes (Middle Tennessee State University)*
7. **Development of Computational Thinking Using TI-Innovation Rovers in High School Mathematics,** *Emily McDonald (University High and University of Tennessee, Knoxville)*
8. **Evaluating the Effectiveness of an Integrative Education Implementation in Biology Classrooms on Increasing Student Sense of Belonging,** *Christel Whitehead & Peggy Biga, (University of Alabama at Birmingham)*
9. **Exploring the Impact of Project-Based Learning in Theory of Flight Classes: A Case Study on Glider Performance as a Predictor of Student Success,** *Collin McDonald (Middle Tennessee State University) Daniel Saio (Auburn University)*
10. **Faculty Perspectives on Using Learning Assistants (LAs) in Undergraduate Introductory Science Classes,** *Monsour Zakariyah & Katy Hosbein (Middle Tennessee State University)*

11. **Libraries Count: Initial Impacts of a Virtual Learning Program for Library Staff Focused on Early Math with Young Children and their Families from Diverse Backgrounds,** *Alissa Lange (East Tennessee State University) Bharat Mehra (University of Alabama)*
12. **Measuring STEM Department Teaching Culture: A Survey Developed Using Self-Determination Theory,** *Alyssa S. Freeman, Mary E. Foley, Sarah Bleiler-Baxter, Aspen Malone, Cassandra Mohr, Andrew R. Puente, Cory Wang, Gregory T. Rushton, & Grant E. Gardner (Middle Tennessee State University)*
13. **Partnerships That Live Beyond Graduation Give New Teachers a Feeling of Belonging and the Stamina to Stay,** *Jill Chambers, Tina Hendrickson, Michael J. Wyss, & Sandra McKell (University of Alabama at Birmingham)*
14. **STEM-STEAM Engagement for Advancing Biomaterials,** *Karen Boykin (University of Alabama at Birmingham), Jonathan R. Bonner, Brian Pillay, Haibin Ning, & Derrick Armstrong (University of Alabama at Birmingham), Coleman Beale & Gabriella Gurau*
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17. **The Beca Embajadores Global Education Program: Assessment and Implications for Self-Efficacy and Interest in Graduate School,** *Wilson Gonzalez-Espada & Jorge Ortega-Moody (Morehead State University), Neftalí Villanueva Pérez (National Polytechnic Institute), Nilesh N. Joshi & Miescha Bycura (Morehead State University)*
18. **Grit, Persistence Strategies, and Retention Recommendations from the Viewpoint of USAFA Graduating Cadets in STEM,** *Wilson Gonzalez-Espada (Morehead State University), Capt. Scott T. Alsid, Maj. Daniel O'Keefe, Maj. Robert Lloyd, & Lt. Col. David C. Meier (U.S. Air Force Academy)*
19. **The Disconnect Between Undergraduate Standard Mathematics and Modern Applied Mathematics: A Literature Review,** *Cory Wang (Middle Tennessee State University)*
20. **Towards Leveraging AI to Provide Automatic Code Review in a Software Engineering Course,** *Esteban Parra & Sophia Willingham (Belmont University)*
21. **Undergraduate Engineering Project in Embedded Systems Course Guided by External Collaboration and Needs,** *Abidin Yildrim, Jonathan D. Kinney, Ryan L. Trudeau & Scott Brande (University of Alabama at Birmingham)*

6:30 pm – 8:15 pm **Dinner and Keynote Presentation – Alumni House**
Keynote Speaker - Dr. Michael Saag,
University of Alabama at Birmingham

8:30 pm – 10:00 pm **Social Hour – Monday Night Social Club**

Saturday, January 11

7:30 am - Close Registration – Heritage Hall Lobby

8:00 am – 9:00 am Breakfast – Heritage Hall Lobby

9:00 am – 11:45 am Parallel Oral Sessions – Heritage Hall

Oral Presentations – Session 3 (Biology and Chemistry Education)
Heritage Hall, Room 104 Facilitator: Dr. David Crisostomo

9:00 am	**Introductory Remarks**
9:05 am	**From Microevolution to the Common Ancestry of Life: The Role of Religiosity, Understanding, and the Context/Scale of Evolution in Students' Acceptance of Evolution,** *Rahmi Aini, Madison Stewart & M. Elizabeth Barnes (Middle Tennessee State University)*
9:25 am	**One Lesson on Science Communication Can Improve Undergraduate Biology Students' Communication About Culturally Controversial Science Topics (CCSTs)**, *Katie Coscia, Donye Asberry, Casey Epting, Alexa Summersill, & M. Elizabeth Barnes (Middle Tennessee State University)*
9:45 am	**The Biology Café: Learning in a Social Setting,** *Mickie Powell, Megan Gibbons, Cynthia Tant & Ketia Shumaker (University of Alabama at Birmingham)*
10:05 am	**Navigating Disclosure: How Does Context Affect the Decisions of Neurodivergent STEM Students During Group Work?** *Mariel Pfeifer & Mason Barker (University of Mississippi), Abigail Graham (Thomas Jefferson University), Madison Greene, Kate Leonard, & Maggie Vander Sys (University of Mississippi) & Stephen Podowitz-Thomas (Thomas Jefferson University)*
10:25 am	**Break**
10:45 am	**Exploring the Association Between Communicating About Spectral Data and Acute Awareness of Stigma Attached to One's Gender Among Women in Postsecondary Organic Chemistry Courses,** *Megan Connor, Ally Parvin & Alex Browning (Samford University)*
11:05 am	**Developing the Future of Safer MRI Contrast Agents: An Advanced Undergraduate Chemistry Lab Experience,** *Aaron Alford (University of Alabama at Birmingham), Samith Jayawardana (University of Alabama), Zachary Cuny (University of Alabama at Birmingham), Gayan Wijeratne (University of Alabama) & Mark Bolding (University of Alabama at Birmingham)*
11:25 am	**Beg, Borrow, and Steal- Adapting Existing Games for Chemistry Courses,** *David Crisostomo (Auburn University)*

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Heritage Hall, Room 121 Facilitator: Dr. Ash Curtiss

9:00 am	**Introductory Remarks**
9:05 am	**From Silos to Synergy: Exploring the Connection Between Foundry-Guided Activities and Holistic, Interdisciplinary Engineering Education,** *Andrea Arce-Trigatti, Pedro E. Arce & J. Robby Sanders (Tennessee Tech University)*
9:25 am	**High School Student Rankings of Hands-On Activities to Introduce Electrical Engineering During Participation in a Weeklong Residential STEM Camp**, *Todd Freeborn & Andrea Ziegler (University of Alabama)*
9:45 am	**Undergraduate Views of the Nature of Mathematics,** *Christopher Bonnesen & Jeremy Strayer (Middle Tennessee State University)*
10:05 am	**Measurement View Reasoning: How do Preservice Teachers Use Representational Approaches to Think About Fraction Division?** *Kingsley Adamoah & Jeremey Strayer (Middle Tennessee State University)*
10:25 am	**Break**
10:45 am	**Undergraduate Students' Nature of Mathematics in an Introduction to Proof Course,** *Jordan Kirby (Francis Marion University)*
11:05 am	**Enhancing Student Engagement and Teacher Perceptions Through Desmos Classroom Activities in High School Mathematics,** *Emily McDonald (University High and University of Tennessee, Knoxville)*
11:25 am	**Exploring the Impact of Automated Assessments in a Quantitative Methods Course,** *Raluca Clendenen & Brad Schleben (Belmont University)*

12:00 pm–1:00 pm Lunch – Heritage Hall, Lobby

1:00 pm– 3:00 pm Parallel Oral Sessions – Heritage Hall

Oral Presentations – Session 5 (Science Education)
Heritage Hall, Room 104 Moderator: Christel Whitehead

1:00 pm	**Introductory Remarks**
1:05 pm	**Comparison of Student Reflections on their Undergraduate Research Experiences in Chemistry and Biology**, *Chazzidy Harper (Kennesaw State University)*
1:25 pm	**Undergraduate Student Conceptions & Sources of Knowledge of Reproduction & Pregnancy,** *Staci Johnson, John T. Locke (Southern Wesleyan University) & Riley Young (Mississippi State University)*
1:45 pm	**Ongoing Findings from a Systematic Review of the Identity Negotiations of Doctoral Students in the Natural Sciences,** *Stephanie Berg, Case Kennedy, Avery Hodges & Mariel Pfeifer (University of Mississippi)*
2:05 pm	**Closing Remarks**

Oral Presentations – Session 6 (Chemistry and STEM Education)
Heritage Hall, Room 121   Moderator: Dr. Rachel Prado

1:00 pm	**Introductory Remarks**
1:05 pm	**Building an Immersive and Inclusive Organic Chemistry Learning Experience,** *J. Rachel Prado (Auburn University), Vanessa Falcao, Allie Brandriet, Ali Sattari*
1:25 pm	**Could Exam Retake Policies Serve as an Avenue for Advancing Diversity, Equity, and Inclusion in Chemistry Education?** *Tasneem Siddiquee (Tennessee State University) & Jesmin Akther (Nashville State Community College)*
1:45 pm	**Mathematically Minded: A Case Study Exploring a Foundry-Guided Course to Improve STEM Students' Critical Thinking Skills through a Historical Markers Database Activity,** *Andrea Arce-Trigatti, Anna Donalies, Gideon Eduah & Ada Haynes (Tennessee Tech University)*
2:05 pm	**STEM Graduate Teaching Assistants: Exploring the Relationship Between Autonomy, Discontentment, and Self-Efficacy,** *Alyssa Freeman, Beari Jangir, Marco Said, Chelsea Rolle, Kadence Riggs & Grant E. Gardner (Middle Tennessee State University)*
2:25 pm	**Levers and Barriers to Graduate Students Teaching Professional Development (GS TPD): Results from Expert Consensus Using Delphi Methodology,** *Erik Akuoko & Grant E. Gardner (Middle Tennessee State University)*
2:45 pm	**Closing Remarks**

EARLY CAREER PANEL

JANUARY 10, 2025
1:30-3:00PM
UAB HERITAGE HALL 104

SESSION SPONSORED BY

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EARLY CAREER PANEL

We are excited to kick off SSERC 2025 with the interactive Early Career Panel, sponsored by The University of Alabama at Birmingham. One of the conference's key priorities is to create an inclusive and supportive environment for graduate students and early-career professionals.

The Poster Session is a key event that particularly appeals to this group, offering an accessible platform for sharing research and engaging with the community. Through events like the Early Career Panel, we aim to foster networking opportunities and create connections across different stages of professional development.

We encourage attendees at all career stages to join us for both the panel and the poster session. These events provide a chance to support and connect with emerging researchers, while also enriching the broader conference experience. Whether you're just starting out or further along in your career, we look forward to seeing you there!

DR. J. RACHEL PRADO

AUBURN UNIVERSITY
DEPARTMENT OF CHEMISTRY

DR. AMY CHATHAM
Moderator

THE UNIVERSITY OF ALABAMA AT BIRMINGHAM
CENTER FOR TEACHING AND LEARNING

DR. ERIN ROWLAND

MIDDLE TENNESSEE STATE UNIVERSITY
DEPARTMENT OF BIOLOGY

DR. MICHELLE WOOTEN

THE UNIVERSITY OF ALABAMA AT BIRMINGHAM
DEPARTMENT OF PHYSICS

SARVANI PEMMARAJU

MIDDLE TENNESSEE STATE UNIVERSITY
DEPARTMENT OF MATHEMATICS

EARLY CAREER PANELISTS

DR. AMY CHATHAM

DIRECTOR, CENTER FOR TEACHING AND LEARNING, UAB

Dr. Amy Chatham currently serves as the Director of UAB's Center for Teaching and Learning, a position that utilizes her deep passion for fostering meaningful learning experiences and prioritizing faculty development. She holds a Doctorate in Health Education and Promotion and an MSPH in International Health. Her work and teaching have focused on enhancing engagement, knowledge, and skills in diverse learning environments.

DR. J. RACHEL PRADO

SENIOR LECTURER, AU

Dr. J. Rachel Prado is a Senior Lecturer in the Department of Chemistry and Biochemistry at Auburn University, where she has been teaching since 2019. She received her B.S. and Ph.D. in chemistry from the University of Alabama at Birmingham and completed a teaching postdoc at the University of California, Los Angeles. Dr. Prado specializes in teaching large lecture sections of general and organic chemistry in a flipped classroom style, with a focus on scaffolding and group work to foster a sense of belonging among her students

DR. ERIN ROWLAND-SCHAEFER

RESEARCH FELLOW, MTSU

Erin Rowland-Schaefer is a postdoctoral research fellow at Middle Tennessee State University studying science communication education in biology courses. She received her Ph.D. in Biological Science from Northern Illinois University, where she studied tallgrass prairie small mammals and their responses to land management. During her Ph.D., she discovered a passion for teaching and education research and also led a project developing an issues-based lesson on landscape ecology using the data from her dissertation.

DR. MICHELLE WOOTEN

ASSISTANT PROFESSOR, UAB

Michelle Wooten is an assistant professor of astronomy education at the University of Alabama at Birmingham, where she welcomes the world of astronomy to hundreds of non-science majors every semester. 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.

SARVANI PEMMARAJU

GRADUATE TEACHING ASSISTANT, MTSU

Sarvani Pemmaraju is a doctoral student in Mathematics and Science Education at Middle Tennessee State University. She received her master's in computer science from Middle Tennessee State University and her bachelor's from India. As a graduate teaching assistant, she has been teaching mathematics content courses for elementary preservice teachers. She also works for the Mathematics Teacher Education Partnership (MTEP) project as a research assistant.

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BANQUET

KEYNOTE SPEAKER

DR. MICHAEL SAAG

THE UNIVERSITY OF ALABAMA AT BIRMINGHAM

FRIDAY JANUARY 10, 2025
6:30-8:15PM
UAB ALUMNI HOUSE

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KEY NOTE SPEAKER SPONSORED BY

Mathematics and Science Education Doctor of Philosophy Program

Keynote Speaker

Dr. Michael Saag
School of Medicine
The University of Alabama, Birmingham

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 Op-ed 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.

ORAL PRESENTATIONS

AUTHORS AND ABSTRACTS

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SOUTHEASTERN STEM EDUCATION RESEARCH CONFERENCE

2025

An Examination of the Efficacy of an Aerospace Living Learning Community

Timothy Rosser
(Middle Tennessee State University)

Living-Learning Communities (LLCs) are commonplace in modern higher education and can take on any number of different forms, their academic benefits to students have been well established. An LLC may be as simple as a group of students with a common area of educational focus living together in a residence hall, to a fully integrated curricular experience designed to support learning. A study examining the impact of a STEM living-learning community on students' GPAs found a significant difference between participants and non-participants in the LLC. The grade point average of students in the LLCs were 26% higher than students who did not participate in the LLC. The academic benefits students are provided through the living-learning community structure allow students to be fully immersed in an academic program and community, which has benefits in and beyond the classroom. A study conducted at the University of Michigan examined participants in the Women in Science Resident Program (WISE RP) LLC. The conclusions of this study found that first-generation students who participated in the WISE RP LLC were more likely to continue their education past the undergraduate level. First-generation participants in the WISE RP LLC were three times more likely to obtain a master's degree in science than those students who did not participate (Maltby, et al., 2016). Little research on LLCs exists about aviation or aerospace students and the unique issues they face. This study focused on the effect residency in the Middle Tennessee State University (MTSU) Aerospace Living-Learning Community (ALLC) has on student performance, measured by course grades and GPA. We also examined the effect of residency status and gender on sense of community within the ALLC, the department, and the university. An additional area examined was the intent of LLC and non-LLC students to pursue graduate education.

The population for this study was all students enrolled in an introduction to aerospace course taught in the fall semester. The research questions that directed this study were:

1. What is the effect of residency status on student academic performance?
2. What is the effect of residency status and gender on a respondent's sense of community?
3. What is the effect of residency status on a respondent's intent to pursue graduate education?

The hypotheses for this study are:

1. Ho_1 Residency status does not have an effect on student academic performance.
2. Ho_2 Residency status and gender do not have an effect on respondent's sense of community.
3. Ho_3 Residency status does not have an effect on a student's intent to pursue graduate education.

An online survey was developed and administered to the students. Questions examined gender, residency status, and intent to pursue graduate education. The Brief Sense of Community Scale was used to measure the respondents' sense of community. To examine RQs 1 and 3, a t-test of independent means was conducted, with a two-way ANOVA conducted to examine RQ 2. Results indicated a significant result for RQ 1 and RQ 3. Results for RQ 2 indicated a significant result for gender and residency status.

Results of this study support findings in prior literature. The findings of this study suggest that residency in an Aerospace Living Learning Community has a positive effect on a student's academic performance, sense of community and their intent to pursue graduate education. The aerospace students at MTSU face challenges that are unique to their chosen course of study. The support these students feel as a result of being a part of a smaller, unique community helps them face these challenges.

Maltby, J. L., Brooks, C., Horton, M., Morgan, H. (2016). Long Term Benefits for Women in a Science, Technology, Engineering, and Mathematics Living-Learning Community. Learning Communities Research and Practice, 4(1), Article 2. Available at: http://washingtoncenter.evergreen.edu/lcrpjournal/vol4/iss1/2

Exploring How Low-Income Students Navigate Inequities in Undergraduate Research Experiences

Emma Goodwin (University of Georgia),
Sailor Dereadt, Jasmine Goode, Bec Kalfus, Gailan Khanania, Laura Pang,
& Sara Brownell (Arizona State University)

Background and Significance

Participation in undergraduate research experiences (UREs) is known to be a positive and influential experience for science majors, and can increase motivation and interest in science, content knowledge and research skills, and retention in science (NASEM, 2017). However, these experiences have traditionally been available to students as an extracurricular experience, which students must seek out and often volunteer in during their free time (Bangera & Brownell, 2014). Guided by critical theory (Celikates & Flynn, 2023), we hypothesize that the structure of UREs presents inequities that systematically disadvantage low-income students from equitably participating in and benefiting from UREs. Through an interview study, we explored how the structure of mentored UREs challenge participation for low-income students and identify the factors that can mitigate these challenges.

Methods

The interview protocol and data analysis were informed by undergraduate members of the research team who participated in this work as part of a course-based undergraduate research experience, and who all had personal experience as undergraduate researchers from low-income backgrounds in a science faculty member's lab. Interview questions were designed specifically to explore how students' low-income background impacted their UREs. We recruited interview participants from a pool of nationwide survey participants, selectively contacting students who had 1) participated in mentored undergraduate UREs and 2) disclosed they were from a low-income background and/or had struggled financially in college. We conducted online interviews with 22 students from 16 universities.

To develop the codebook, the research team iteratively read through interview transcripts, meeting regularly to draft and define codes that captured emerging ideas in the transcripts until saturation was reached. Once the codebook was finalized, each transcript was read and independently coded by four to six researchers, and all coding decisions were coded to consensus. After coding all 22 transcripts, members of the research team worked in pairs to review all coded segments and ensure that the codebook was applied consistently and accurately.

Findings

In interviews, nearly all participants framed time spent in UREs as a high-stress trade-off of time spent in paid employment, given students' competing priorities of paying for tuition and meeting their basic needs. Even when students were paid for their research, students often needed to balance additional paid employment or encountered increased financial struggles because their research stipends were lower than what they would earn in an outside job. One participant explained: *"Having three jobs sucks. That will take your energy out and not give you as much energy to devote to the research for sure."*

Participants also frequently explained that their commute was a significant limiting factor to their research participation, because they often lived further from campus in more affordable housing and/or relied on public transportation. Limited money for gas, the significant time it took to commute to campus, or limited access to public transportation meant that students sometimes had to limit their engagement in research activities or social activities with their research group. One participant, who could not afford to live near campus, explained, "*For the students who live [close to] campus, going to the lab on a weekend is not that big a deal… But for me, it's a larger investment of my time and a lot of gas money… [There's an] expectation [from my research mentor] that I can just drop everything and go into lab."*

Having a supportive research mentor who strived to understand their students' experiences and respected students' time and financial situation was often essential for low-income students to have a positive and productive research experience. Many participants explained that they were only able to participate in research because their mentors worked with them to develop accommodating research schedules. Most interviewees received financial compensation and/or earned course credits for their URE. In addition to helping them meet their basic needs and often enabling them to participate in research at all, students described that receiving financial compensation justified and validated their decision to dedicate more time and effort in a research experience.

Conclusion

UREs can be costly activities for low-income students, and faculty, who often are from higher-income backgrounds, may not recognize the extra challenges that low-income students face in UREs. With this work, we will expand awareness of the ways that traditional mentored UREs may systematically disadvantage low-income students. We will also highlight what universities and research mentors can do to alleviate these challenges for low-income students and increase equitable research participation.

References

Bangera, G., & Brownell, S. E. (2014). Course-Based Undergraduate Research Experiences Can Make Scientific Research More Inclusive. *CBE—Life Sciences Education*, *13*(4), 602–606. https://doi.org/10.1187/cbe.14-06-0099

Celikates, R., & Flynn, J. (2023). Critical Theory (Frankfurt School). *The Stanford Encyclopedia of Philosophy, Winter 2023 Edition*. https://plato.stanford.edu/Entries/critical-theory/

National Academies of Sciences, Engineering, and Medicine. (2017). *Undergraduate Research Experiences for STEM Students: Successes, Challenges, and Opportunities*. National Academies Press. https://doi.org/10.17226/24622

Specifications Grading in Data Science Education: Implementation and Evaluation of Proposed Student Outcomes

Brandon Yik (University of Georgia),
Loreto P. Alonzi III, Brian M. Wright, & Marilyne Stains (University of Virginia)

Introduction

Instructional reforms in science, technology, engineering, and mathematics (STEM) courses have predominantly focused on teaching practices. An area that has been gaining attention in recent years is grading reforms. Alternative grading schemes emphasize the learning process over evaluative grades on individual assignments, and one such popular alternative grading scheme is specifications grading (Nilson, 2015). Specifications grading has been proposed to positively benefit both students and instructors and promote equity. Specifications grading has also been proposed to have positive outcomes related to students including motivating students to learn and excel, fostering students' sense of responsibility for their grades, reflecting student learning outcomes, giving students feedback they will use, reducing student stress, and making expectations clear. Additionally, it is also hypothesized that specifications grading is a simpler grading scheme that allows instructors to assess students authentically while upholding high academic standards.

For these reasons, an introductory data science course, Foundations of Data Science, at the University of Virginia was developed using a specifications grading scheme (Alonzi III et al., 2024). This course integrates flexibility, student agency, and second chances. Five assignment types (i.e., weekly lab, reading, case study, look ahead, and essay) form grade bundles that map onto final course letter grades. Students must meet the requirements for a grade bundle to earn that letter grade. To evaluate the effectiveness of this specifications grading scheme, we leveraged the newly developed Perceptions of Grading Schemes (PGS) instrument which explores students' perceptions of the implementation of specifications grading as compared to traditional grading schemes experienced in other STEM courses (Yik et al., 2024). This psychometric instrument is a five-factor model that aligns with some of the proposed student-centered outcomes of specifications grading: reduce student stress, make clear expectations, reflect student learning outcomes, useful feedback students will use, and motivation to learn and excel.

Research Questions

Two research questions guide this study:

1. What validity and reliability evidence support the use of the Perceptions of Grading Schemes (PGS) instrument in an introductory data science course?
2. What are students' perceptions of specifications grading in an introductory data science course?

Methods & Data Analysis

Methods. Students enrolled in two semesters (Fall 2023 and Spring 2024) of the Foundations of Data Science course were invited to participate in the study which included an online survey containing the 24-item pilot version of the Perceptions of Grading Schemes (PGS) with prompt directions adapted for the Foundations of Data Science course. Overall, there was a 55% consent rate (n = 129). The data sets from both semesters were combined for analysis.

Data Analysis. Statistical analyses were performed in R (R Core Team, 2024). Confirmatory factor analysis (CFA) was performed using the previously published factor structure: a 15-item, single-order, correlated factors model with three items loading onto a total of five factors. CFA model fit was evaluated using the χ^2 statistic, comparative fit index (CFI), Tucker–Lewis index (TLI), standardized root-mean square residual (SRMR), and root mean square error of approximation (RMSEA) (Bentler, 1990; Bentler & Bonnet, 1980; Hu & Bentler, 1999; Steiger, 1990; Tucker & Lewis, 1973). Internal consistency was evaluated through a series of stepwise CFA with increasing equality constraints (Komperda et al., 2018). McDonald's ω is the most appropriate measure for internal consistency for this data set and McDonald's ω coefficients were calculated. Standardized mean factor scores with associated 95% confidence intervals were calculated and plotted to represent students' perceptions in the Foundations of Data Science course when compared to traditional grading schemes implemented in other STEM courses.

Results

CFA results indicate that previously published factor structure demonstrates acceptable fit to PGS instrument data collected from the Foundations of Data Science course. Single factor congeneric models demonstrate acceptable fit for all PGS instrument subscales which suggest unidimensionality of instrument subscales. Single factor tau equivalent models do not exhibit acceptable fit indicating that McDonald's ω is the most appropriate internal consistency measure. All PGS factor subscales demonstrate acceptable reliability.

However, students' perceptions of the specifications grading implementation in the Foundations of Data science course vary between factors. Three of the factors align with the proposed outcomes of specifications grading: *Raises Anxiety, Clear Expectations*, and *Useful Feedback*. Students perceive that other STEM courses that use traditional grading are more representative of raising anxiety, and thus students perceive less anxiety in this specifications-graded course. Additionally, students perceive that two factors are equally representative of both traditional and specifications grading schemes: *Reflect Student Learning Outcomes* and *Promotes Motivation to Learn*.

Conclusion

Study findings demonstrate that data collected form the Foundations of Data Science course show acceptable fit to the previously published factor structure and acceptable reliability of instrument subscales. This is the first example that establishes that the Perceptions of Grading Schemes (PGS) instrument can be adapted to a discipline outside of chemistry and be used to collect valid and reliable data. Findings also indicate that students' perceptions regarding specifications grading do not necessarily align with the proposed student outcomes even when implemented in its purest form. Therefore, further refinement of the specifications grading implementation is needed to potentially align students' perceptions with all the proposed student outcomes.

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Complex Systems, Emergence, and 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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Increasing Success and Retention of Female Students in Computer Science by Enhancing Two Key factors: Math Proficiency and Programming Skills

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Introduction

In the past 20 years, there has been a large decline in the number of females pursuing college degrees in computer science and information technology (IT) [1][2][3]. According to the National Center for Education Statistics [4][5], only 21.3% of all computer science degrees in nationwide was earned by women between 2019 and 2020, which dropped even lower to 10.4% for women of color. The U.S. Department of Labor also shows that in 2016 only 24.7% of computer science professionals and 15.1% of engineering professionals were female, although women constituted close to half of the total workforce [1][6]. Recent studies [7][8] show that more and more female students give up on their major and career to a single college class: Calculus I. Compared to male students, female students are 1.5 times more likely to drop out of the STEM majors after taking Calculus I. For female students in computer science, another main obstacle on the way to the successful completion of their degree is programming skills [9][10][11]. The BRAID (Building, Recruiting and Inclusion for Diversity) research team has pointed out that "Women are socialized to feel that they can't fail and that they have to achieve perfection, so when their code doesn't run, women often feel discouraged about their own abilities" [12]. There is a widely known phenomenon of a "sophomore slump" in college education [13][14][15][16], which refers to a possible lower GPA and retention rate in the sophomore year. For example, the enrollment number in the second year had significantly dropped in the Computer Science class: "Introduction to Computer Science I" at Yale University in 2016 [17].

Therefore, we aim to improve both the GPA and retention rate of female students in computer science or related majors, especially students of color, by helping them promote math interests and build up mathematical proficiency and programming skills during the early stage of their college study. Our work has aligned seamlessly with the major goals of the U.S. Department of Education (USDE), the Tennessee Department of Education (TNDE), the Tennessee Board of Regents (TBR), Middle Tennessee State University (MTSU), and Achieving the Dream (ATD) for promoting diversity and equity in all levels of education.

Research Questions

Specifically, three research questions are targeted in this study.

1. How to build up math confidence for female undergraduate students at their early stage?
2. How to promote programming interests for female undergraduate students at their early stage?
3. How to prevent from or minimize the impact of the "sophomore slump"?

Methodology and Timeline

This project addresses the specific need for improving GPA scores and retention rate of female students in computer science or related majors, especially female students of color, by promoting mathematical proficiency, programming skills, and confidence. We seek efficient and effective ways to engage minority and underrepresented students by providing learning communities [18], organizing seminars with fun activities/projects, including Python programming, encryption/decryption in cybersecurity, Lego robotics building and programming, applications in mathematics, etc., inviting female role models to talk about their experiences and share thoughts with the students, and developing a summer educational and research enrichment program.

This is a year-long (2022-2023) process including recruitment of students, various activities throughout the fall 2022 and spring 2023 semesters followed by a summer 2023 educational and research enrichment program. The details of the activities carried out in each semester are tabulated in the following table.

Semester	Activity	Description
1. 2022 Fall 2. 2023 Spring 3. 2023 Summer 4. 2023 Fall (Extension)	Initial Recruitment (Within the first two weeks of the semester)	Flyers on bulletin boards, classroom announcements for lowerdivision classes, student organizations – Association for Computing Machinery (ACM), Computer Science Connections (CSC), announcements through the department chair.
	Learning Communities	Divide students into small study groups so they can easily meet to discuss and help each other regularly. Biweekly meetings with faculty mentors for questions and further discussions towards enhancement of programming and math skills.
	CS/Math Tutoring Lab	Incorporate bite-sized learning
	Bi-weekly Meetings	Role models -- Invite female faculty members to talk about their experiences and research, and senior female student or graduates to share their stories.
		Workshops with hands-on experience for female students in a variety of Computer Science and Math activities, such as simple coding for robotics, data encryption/decryption, as well as math games and their Python implementation.
	Lego Robotics Competition	Build, program, test and debug a Lego robotics based on a given topic during the meeting.

Data Analysis and Results

The project aims to boost the success and retention of female students in computer science and related majors by focusing on improving two crucial factors: math proficiency and programming skills. We conducted a pre-activity survey at the beginning of each semester to learn the interests, needs and expectations of the student participants, and a post-activity survey at the end of each semester to assess the outcomes and students' satisfaction of the program, respectively. We have achieved a big success and summarized the results below.

- Classroom activities focusing on application concepts and coding have been highlighted as most beneficial, suggesting an enhancement in practical skills, which could positively influence students' GPAs.
- Enjoyment in building and coding Lego Robots has been unanimously reported, reflecting an engaging and hands-on learning experience that could contribute to student retention and academic success, especially the underrepresented population.
- A consistent acknowledgment of the program's benefits to the students' studies has indicated a positive impact on academic support, potentially affecting both GPAs and retention rates.
- Increasing motivation levels in pursuing a Computer Science or Math major and a successful graduation across the semesters has suggested rising commitment and confidence among the students, which aligns with our goal of increasing student retention and graduation rates.
- The positive reception of guest speaker sessions and the willingness to attend future events and programs have demonstrated a sustained interest in the field, which is critical for a long-term student retention program.

Conclusion

Our project has succeeded in creating a positive and beneficial educational experience and a supportive learning environment for our students. It has expanded the students' horizons through various lectures, discussions, and talks, especially those led by female professionals and role models from both industry and academia, and hands-on building/coding experiences. We believe that the positive outcomes will be beneficial to the targeted group of female students, including an increased sense of confidence and proficiency in both computer programming and mathematics.

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STEMMing The Tide – Empowering Youth to Meet Coastal Environmental Changes

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This presentation highlights the progress of a 5-year study to utilize and assess a community of practice approach in designing an environmental justice and locally relevant curriculum that aligns directly with the Alabama State science and social studies standards. The curriculum will initially focus on 6th-8th grade students attending MCTS in Africatown. It can be expanded to include other at-risk schools in the Mobile district, summer camps and/or after-school programs**.** This curriculum utilizes best practices in early STEM pedagogy, service-learning, and a focused theme on the connections between the local environment, community, and individual health. Students from Africatown and surrounding communities in Mobile, Alabama will explore the impacts of years of environmental injustice and pollution in their neighborhoods. Specifically, they will learn how the quality of the local environment impacts human and community health and how current policies, climate change, and industrial pollution impact schools and neighborhoods.

To contextualize in-class learning, students partner with community leaders and organizations to develop and participate in service projects funded by this grant aimed at revitalizing and restoring their neighborhoods, parks, and ecosystems. This model provides students with a sense of self-agency by empowering them to become agents of change while creating impactful learning interventions that allow students to achieve the state science and social studies standards. The culminating research and work done by students, teachers, and community partners would then be highlighted and shared with the broader community at this program's biennial environmental justice and climate change conference.

Assessment strategies include the analysis of annual ALSDE report card data, pre/post student surveys each year, teacher reflections, and workshop participant feedback. Currently, at the start of year 3, the workshop participant feedback demonstrated a strong appreciation for the community of practice approach in curriculum design from both community agencies and teachers; science proficiency nearly doubled from year 1 (9.09%) to year 2 (17.19%); and teachers reported increased student engagement with the material as a result of project-based learning.

Experimental Measurement and Establishment of Communication Metrics Using a Highly Interactive and Visually Enhance Robot Platform

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Introduction

Among many unique challenges in STEM education, those challenges can be categorized into different groups by their origin and connection. Education requires at least two entities involved in its activities: content providers and content consumers. In addition, we can also consider the surrounding environment, which could be a location, culture, or any other external factors to be considered around education. The challenges in STEM education can also be categorized by its topics into several subtopics, which include 1) gender gap disparities [1-4], 2) racial and ethnic group inclusion [5-7], 3) students with disabilities [8-9], 4) lack of STEM teachers [10-11], 5) retention and sustainability of students [12-14], and 6) faculty-student connections [15-16]. Most of the aforementioned challenges are more related to external factors-initiated problems rather than ones of content suppliers or consumers. These are longer-term and continuous efforts that require actions from social, cultural, environmental, and institutional aspects, which is an action for faculty and administrators in higher education to perform for direct and substantial changes. The authors of this paper focus on the communication between content providers and consumers, faculty, and students. Efficient communication is crucial for influencing students' professional trajectories. Effective communication, both via spoken and non-spoken means, by teachers has a vital role in the academic achievements of pupils [17]. Effective communication catalyzes pupils to enhance their skills and fosters a strong work ethic. Consequently, educators must engage in good communication with their pupils. Departments should prioritize the improvement of students' skills through diverse communication methods [18]. Good communication skills in instructors are essential for students' academic achievement and career growth. In the classroom, teachers predominantly convey instructions through verbal communication. Inadequate communication skills among professors might impede students' acquisition of knowledge and limit their academic advancement [19]. Students must be able to differentiate between what is morally correct and incorrect, a talent greatly influenced by the communication techniques teachers use in the classroom.

Problem Statement

The importance and implications of communication between teachers and students are vital because education is based on the communication between two entities, faculty, and students, and the knowledge, experiences, and methodologies flow interactively between them. Most communication works are focused on or related to tools, curriculum, contents, and educational technologies to bring in their pedagogies to apply and adopt for better outcomes. However, the more fundamental aspects and insights of communication, such as emotional human factors that students initiate and keep toward teachers, have not been analyzed. In other words, the relationship between pedagogical approaches toward students' perception and outcomes has not been studied.

Therefore, it is of interest to identify and measure some of the intrinsic and fundamental factors of emotions that we all have in interactions and to establish the performance metrics extended to the classroom outcomes. As an initial study, the authors in this paper focus on measuring the comfort and trust of humans when we interact with others under various scenarios and situations.

Methodologies

Vision is an essential and complex sense that has evolved to help us navigate and survive in our environment. It plays a critical role in decision-making, allowing us to form quick judgments and understand the emotional and social cues of others. However, relying solely on visual information can sometimes lead to biased or incomplete judgments, making it essential to recognize and counteract the first impression bias. By acknowledging the limitations of vision and seeking out additional information, we can make more informed decisions in our daily lives.

Given the critical role vision plays in shaping human perception and decision-making, it is no surprise that visual cues significantly influence social interactions, including those involving race. Our reliance on first impressions, formed primarily through visual stimuli, can lead to biases that affect how we perceive and respond to others. Understanding these visual influences is crucial for exploring implicit biases and social behaviors in the context of racial dynamics. This is where innovative tools, such as the Furhat robot [20], can offer a new dimension to research, allowing for the controlled study of these dynamics in real-time interactions. So, the authors in this paper use the Furhat robot to visually stimulate people's reactions.

One of the significant benefits of using the Furhat robot is that it engages multiple senses, particularly vision, which is central to human decision-making and perception. Participants answer survey questions and experience a simulated interaction, providing a more authentic context for examining how racial dynamics influence comfort levels and attitudes. Visual cues, such as facial expressions, play a critical role in forming first impressions, and by using the robot, researchers can assess how participants react to these cues when presented with individuals of different racial backgrounds. This adds depth to the data that traditional surveys would miss, allowing for more nuanced insights into racial biases.

Furthermore, the robot eliminates some of the limitations of traditional surveys, such as the potential for external bias or distractions during self-reported questionnaires. With the robot conducting the study, researchers can ensure that participants consistently interact with the same stimulus, making the data more reliable. Using the robot also helps reduce socially desirable responses, as participants interact with a machine rather than a human interviewer, allowing for more honest and accurate reflections of their feelings toward different races.

Significance

One of the significances of this research is that the procedure and results of the experiment establish the performance measuring metrics of communication, which underscores the importance of communication in classrooms for better and effective teaching pedagogies and methodology development. The highly interactive and visually enhanced robot system, Furhat, continuously performs the measurement of other factors in humans related to race, gender, fun, reliability, and so on.

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Science Identity Development of First-Generation College Students in Two Learning Assistant-Supported Classrooms

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Background

Do you see yourself as a science person? A scientist? The answers to these questions may help to define your Science Identity, i.e., who you are in relation to science (Carlone & Johnson, 2007; Gee, 2000). Extensive evidence shows that Science and Discipline-specific Identities significantly impact student persistence and career goals in STEM, particularly for those with marginalized identities (Avraamidou, 2022; Carlone & Johnson, 2007; Monsalve et al., 2016). *By exploring how students develop a Science Identity within various settings, we can intentionally design learning spaces to support Science Identity growth for students who are pursuing careers in science disciplines.*

Significance

First-generation (first gen) college students are those whose parents or caregivers did not complete a four-year degree (Redford & Hoyer, 2017). While these students often receive emotional support from their families, they may not receive much guidance in navigating college and STEM careers, creating additional barriers. Most support resources for first-gen students are outside the classroom, requiring extra time many can't spare due to other responsibilities (Pascarella et al., 2004; Stitzel & Raje, 2022). *Bringing resources into the classroom could better support these students and remove barriers to persistence through STEM.* One avenue to introduce resources into the classroom is through the Learning Assistant (LA) Program (Otero et al., 2010). LAs facilitate active learning and provide in-class academic, emotional, and peer support. This provides students with learning, emotional, and other academic support *in class* (Clements et al., 2022; Van Dusen & Nissen, 2020).

Research Questions

How do first-generation college students perceive the development of their science identity in LA-supported science classes?

Data Analysis

This study addressed the research question through qualitative methods in order to explore first-generation students' experiences. First-generation students were recruited from one General Biology I and one General Chemistry I course that were using LAs. Students participated in beginning (n=10), mid(n=7), and end- (n=5) semester semi-structured interviews where they described their experiences with LAs and how these experiences impacted aspects of their science identity. Thematic analysis was used to describe themes across student experiences.

Findings

Three themes related to first-generation student experiences within the two LA-supported courses were described and included three aspects of science identity: vicarious experiences, verbal persuasion, and mastery experiences. First, vicarious experiences with LAs challenged stereotypes in science. Students mentioned that LAs didn't look like typical science people and this made students feel like they could be science people too. Second, verbal recognition provided supportive guidance for students to overcome academic obstacles. Students often described that LAs would verbally encourage them during class and this would help them to continue pushing to understand material. Finally, LAs facilitate mastery and enhance conceptual understanding for students. Students cited LAs pushing for them to understand course material and not just arrive at a prescribed answer.

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From Microevolution to the Common Ancestry of Life: The Role of Religiosity, Understanding, and the Context/Scale of Evolution in Students' Acceptance of Evolution

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Research Background

In evolution education research, there is a consistent negative relationship between students' *religiosity* (the extent to which students identify as religious) and their *acceptance of evolution* (the extent to which they think evolution is scientifically valid) (Barnes, Supriya, et al., 2020; Heddy & Nadelson, 2013; Lombrozo et al., 2008; Mantelas & Mavrikaki, 2020; Manwaring et al., 2015) for different contexts (humans and nonhumans) and scales (microevolution and macroevolution) (Beniermann et al. 2023; Nadelson and Southerland 2012; Sbeglia and Nehm 2019; Barnes et al. 2022; Glaze et al. 2020). In addition, *evolution understanding* (how much students know about evolution) is often positively related to their acceptance of evolution (Nadelson & Southerland, 2010; Rice et al., 2015; Salazar-Enriquez et al., 2023; Sloane et al., 2023; Tavares & Bobrowski, 2018), yet there is limited research on how religiosity may impact the relationship between understanding and accepting evolution for undergraduate biology students in the United States. In this study, we aimed to explore this phenomenon using the following research question: *How does religiosity moderate the relationship between college students' evolution understanding and its acceptance across different scales and contexts of evolution?*

Research Design

The data for this study is part of a larger survey-based investigation of American undergraduate biology classes across 15 institutions and 74 biology courses between Fall 2018 and Spring 2021. Surveys were made available to approximately 16,894 students, with 11,409 responses included in the analyses. The majority of participants were women (68%), Christian (54%), white (48%), and biology majors (53%). Students' religiosity was measured using four items from a published scale (e.g., "I believe in God") (Cohen et al., 2008). Evolution acceptance was assessed with 24 items from the Inventory of Student Evolution Acceptance (I-SEA) (Nadelson & Southerland, 2012), covering microevolution, macroevolution, and human evolution. Responses were on a 5-point Likert scale and averaged for composite scores. Evolution understanding was measured using 13 true/false items from the Evolutionary Attitudes and Literacy Survey (EALS) (Hawley et al., 2011). Students could also select "I don't know enough to answer" to reduce guessing and understanding scores were the proportion of correct answers.

Analyses

To determine the sub-dimensions of factors within the I-SEA instrument, we conducted factor analyses and a six-factor solution was selected based on both statistical criteria and theoretical considerations. To assess if the relationship between evolution acceptance and understanding varied with student religiosity, we used six mixed-effects linear regression using model: *Evolution acceptances ~ Evolution understanding * religiosity + race + gender + religion + biomajor + (1|institution) + (1|course).* Simple slopes analyses were then employed when the interaction was significant to estimate relationships between acceptance and understanding at different levels of student religiosity.

Finding: The relationship between students' understanding and acceptance of evolution depends on their religiosity and the context/scale of evolution.

Six sub-scales were found from the original three subscales of the I-SEA: *microevolution* acceptance split into negatively and positively worded items; *macroevolution* acceptance divided into macroevolutionary change (mostly based on recognition of evidence) and common ancestry of all life; human evolution acceptance split into human change within species and human common ancestry with apes. Linear mixed-effects regressions showed significant interactions between understanding and religiosity predicting acceptance in macroevolution ($\beta = -0.13$, $p < 0.001$), human evolution within species ($\beta = -0.12$, $p = 0.001$), human common ancestry with apes ($\beta = -0.16$, $p < 0.001$), and common ancestry of all life ($\beta = -0.45$, $p < 0.001$). These results indicate that religiosity moderates the relationship between understanding and acceptance in specific evolutionary contexts.

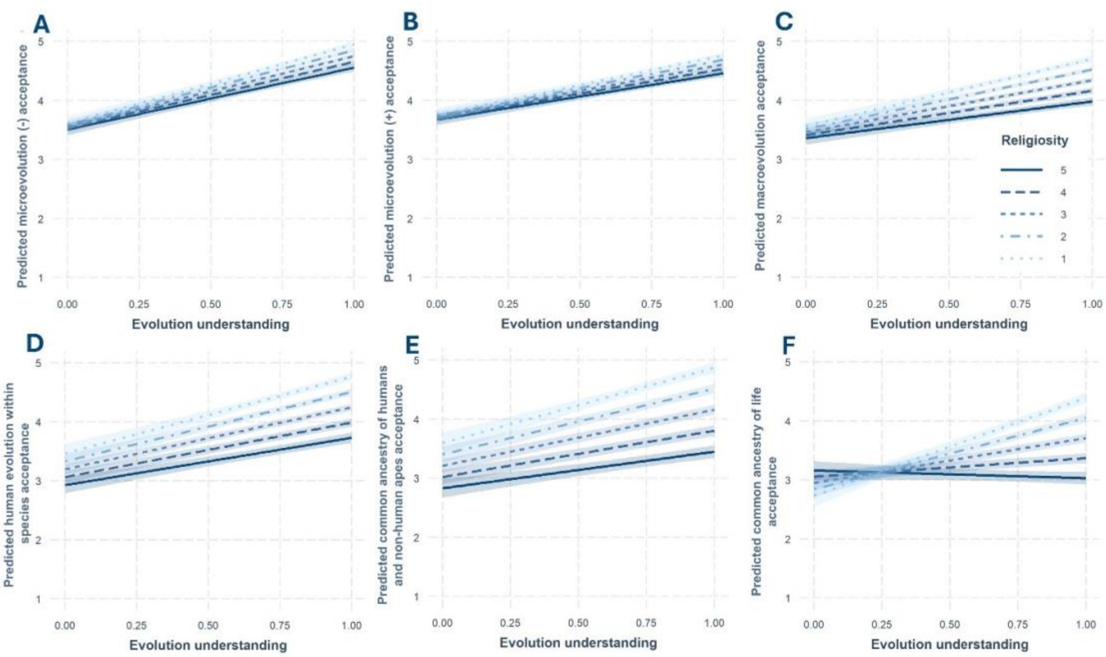

Figure 2: Relationships between students' evolution understanding and acceptance of evolution in 6 different scale/context disaggregated by religiosity level; 1 being the least religious and 5 being the most religious, determined by mixed effects regressions. The interaction between understanding and religiosity was statistically significant except for microevolution (-) and microevolution (+) outcomes ($p > .001$).

The simple slopes analysis demonstrated that the strength of the relationship between students' understanding, and acceptance of evolution varies based on their level of religiosity. Specifically, for the four contexts/scales of evolution where statistically significant interactions were detected, the relationship was weaker among students with high religiosity compared to those with low religiosity, as evidenced by non-overlapping confidence intervals. Notably, for highly religious students, there was no significant relationship between their understanding of evolution and their acceptance of the common ancestry of all life ($\beta = -0.06$, $p = 0.54$).

The significant of research

This is the first quantitative study to our knowledge that has shown that for college biology students, the relationship between evolution understanding and acceptance for college biology students in the United States, is moderated by religiosity. This research also provide evidence for six different scales and contexts of evolution acceptance, including a relatively new construct not previously documented quantitatively: the common ancestry of life. This subscale was originally from the macroevolution scale (Item wording: *"I think all complex organisms evolved from single-celled organisms*" and *"I think that all organisms come from a single common ancestor*"). These items were distinct from the other items not only theoretically, but also in the factor analysis results. Further, these two items showed the most striking results. This subscale was also the only context of evolution for which highly religious students' understanding of evolution was not at all related to their acceptance. This research indicates that accepting the common ancestry of life will be the most difficult for students, and that highly religious students may have the most trouble translating their understanding of evolution to their acceptance of the common ancestry of life.

These findings highlight the need for further research to understand students' conceptions of common ancestry, their acceptance levels, and how understanding and religiosity affect this acceptance. Since our measure included only two items and limited studies have explored this construct, future qualitative work is essential. Such research could provide new insights into students' evolution acceptance and inform strategies to address challenges faced by students, especially those who are highly religious.

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From Silos to Synergy: Exploring the Connection Between Foundry-Guided Activities and Holistic, Interdisciplinary Engineering Education

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Background Literature

Since the beginning of the 21st century, national calls for holistic engineering education have been prolific in the field (Engineering Unleashed, 2024; Grasso & Burkins, 2010; National Academy of Engineering, 2019; The Lemelson Foundation, 2024). These calls aim to focus on holistic engineering education that builds a foundation for students to be able to engage in interdisciplinary work at various intersections in their area (e.g., biomedical sciences, nursing, sociology, etc.). However, consistently, engineering education has faced challenges in integrating interdisciplinary approaches that address holistic problem-solving and problem identification strategies (The Lemelson Foundation, 2024). In this respect, the Renaissance Foundry Model (i.e., the Foundry) provides a pedagogical platform that offers student-teams an opportunity to learn how to leverage major cognitive processes, like knowledge acquisition and knowledge transfer, to integrate new knowledge from different perspectives in the development of a prototype of innovative technology (Arce et al., 2015). Further, the Foundry has been applied to various disciplinary contexts at both the undergraduate and graduate levels in engineering education and other disciplines, with impactful results in students' development of critical thinking and problem-solving skills.

Significance

This study is contextualized in a holistic, interdisciplinary National Science Foundation - National Research Traineeship (NRT) Program that leverages a Foundry-guided approach (Arce et al., 2015) to foster integrative thinking and problem-solving skills among and between students working collaborative in teams (Matthews et al., 2022). Specifically, we look at a class that is required as part of the first year of the program of study for this program, which had 15 NSF-NRT and non-traineeship students enrolled. In this class, students were asked to apply the major pillars of the program, including the Foundry-guided approach to holistic engineering education, as well as training in critical thinking and community-based collaboration frameworks to complete a prototype of innovative technology (Pabody et al., 2023; Wilson et al., 2024). In this contribution, we offer insight into students' growth in specific areas related to interdisciplinary work which adds to the current body of knowledge regarding pedagogical strategies that enhance the effectiveness in engineering education practices. In accordance, this work is significant as it offers a unique opportunity to explore a Foundry-guided approach that is encompassed in a larger program that has learning outcomes specific to interdisciplinary communication and collaboration.

Research Question

For this study, we ask the following research question: In what ways did a Foundry-Guided approach assist student-teams in developing skills relevant to understanding interdisciplinary communication?

Data Analysis Procedure

Specifically, we present preliminary findings using descriptive data analysis for student growth in the areas of (1) Connections to Discipline and (2) Integrated Communication. These data were collected during one semester of one of the NSF-NRT courses and were guided by the American Association of Universities and Colleges' (AAC&U) common skills as found in a modified version of the Integrative Learning AAC&U (2024) VALUE rubric. According to the AAC&U (2024), "Integrative learning is an understanding and a disposition that a student builds across the curriculum and co-curriculum, from making simple connections among ideas and experiences to synthesizing and transferring learning to new, complex situations within and beyond the campus." Rubric scores were taken from various team-based assignments that were Foundry-guided and geared towards students' development of a prototype of innovative technology. Overall, these activities had students exploring design thinking approaches, as well as interactions between each other for the purpose of exchanging new ideas and learning from each other's disciplinary perspectives. For the students in this program, this type of skill was meant to foster a more interdisciplinary, holistic disposition that leveraged the Foundry to engage in collaborative work across different areas of study applicable to the development of a prototype of innovative technology (Arce et al., 2015).

Summary of findings

The preliminary findings reveal that students developed skills related to a deeper understanding of real-world applications through interdisciplinary collaboration and that interdisciplinary, holistic approaches in engineering education improved student outcomes. In terms of Connections to Discipline we found growth in all student-teams' efforts to make integrations from their peers' knowledge to their own discipline in the development of a prototype of innovative technology. In the AAC&U (2024) rubric, this criterion specifically underscores student synthesis, the combination of ideas, and the integration of those ideas into new concepts. Further, we see that in Integrated Communication, student teams excelled in how they leveraged communication between disciplines in a way that, "enhances meaning, making clear the interdependence of language and meaning, thought, and expression" (AAC&U, 2024). As part of this criterion, we observed students engaging in insightful reflection, interactions that solicited different perspectives, and growth through conversation. Implications and lessons learned from these findings connect directly to key areas relevant to the Engineering Unleashed (2024) framework.

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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; 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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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 Biology Café: Learning in a Social Setting

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Background and significance:

Establishing social connections and a sense of belonging in the first year of undergraduate enrollment is critical to student satisfaction and institutional retention (Pedler et al 2021). Further, incorporating social connections within academic arenas can improve student success. Students entering high-enrollment introductory courses may find it difficult to establish social networks, especially when these courses are academically rigorous, fast-paced, and characterized by a high rate of attrition. Forming social connections with peers, however, can be a critical component to help students manage the stress and anxiety that accompanies academically challenging courses (Loseth et al 2022). New challenges at universities (such as changes in technology, increased diversity of the student body, and different pedagogical styles of professors) have created increasing demand for the development of new learning environments (McCune and Entwistle 2011). Current research (e.g., Valtonen et al, 2021) suggests that university students prefer informal learning environments where they can study alone or with peers or just “hang out”. Such settings can meet the increasing needs of universities to address the changing landscape, while also improving opportunities for students to build important social networks with peers.

In order to address this issue within the Biology Department, a team of Introductory Biology Faculty initiated The Biology Café, launched in Fall 2023. The Biology Department in University of Alabama at Birmingham’s College of Arts and Sciences serves ~850 undergraduate Biology majors every year and the majority of those students enroll in our Introductory Biology courses (BY 123 and BY 124) as first-year students. The Biology Café is a dedicated area of common space in the new Science and Engineering Complex that provides a casual setting for both social gathering and peer mentoring for students currently enrolled in our introductory courses.

The Café has been designed to foster student interactions and to help create social connections between peers. Peer facilitators, high-performing undergraduates who have been recruited from past courses and trained to assist current introductory students, staff the Café throughout the day and assist students who have questions about course material. Peer facilitators can instruct and engage students about course concepts as well as study tactics, time management strategies, and metacognition learning skills. Biology students seeking help (or just a place to study) can drop in whenever it is convenient, and they can grab a snack or some coffee. Resources include multiple whiteboards, movable chairs and tables to accommodate individuals or groups of various sizes, a monitor for facilitators to show videos, slides, or online learning tools, and several biology-themed games that students can play while at the Café. Students do NOT receive point incentives for visiting the Biology Café. This project was undertaken as a quality improvement initiative and as such does not constitute human subjects research.

Project questions:

We are still in the beginning stages of development; ultimately, we hope to evaluate the success of the Biology Café by relating individual students' usage of the Café to academic performance in our courses. For this presentation, we took used surveys to evaluate the usage and helpfulness of the Biology Café with the following project questions:

1. What percentage of students in UAB's introductory biology classes utilized the Biology Café, without "point" incentives?
2. How much time did students spend in the Biology Café?
3. How helpful did students find the Biology Café?

Methodology and Analysis

In FA 23, we initiated the Biology Café, and for the semesters FA 23, SP 24, and SU 24, we tracked the usage of this resource, and we surveyed students enrolled in Introductory Biology I and II (BY 123 and BY 124) on how helpful they perceived the Biology Café to be.

Project Questions 1 and 2: Student attendance and total time spent in the Biology Café

We used 3 methods to collect data on attendance and time spent in the Biology Café, including:

1. Records of attendance and time spent in Café via "sign in" and "sign out" sheets
2. Quiz and/or exam questions asking whether students visited the Biology Café for help before each exam (full credit given for any answer)
3. End of semester survey asking approximately how many times each student visited the Biology Café and how many total hours they estimated that they spent there (Extra credit given for survey completion, to encourage participation).

Project Question 3: How helpful did students find the Biology Café?

To assess how helpful students perceived the Biology Café to be, we also asked for quantitative and qualitative feedback about their experience in the End of the semester survey, above. The survey was 11-questions, which included 5 questions (combination of multiple choice, Likert Scale tables, and open-ended) regarding students' and perceived effectiveness of the Biology Café.

Data from the surveys were compiled and descriptive statistics calculated; no comparative analyses were conducted for this study.

Summary of Findings

1. Over 400 BY 123 and BY 124 students visited the Biology Café in during the first 3 semesters of its inception, over 30% of enrolled students in FA 23 and SP 24, and over 50% of enrolled students in SU 2024
2. The total amount of time students spent in the café varied from <1 hr to >25 hr over the course of the term; most spent between 1-5 hr.

3. Overall, students reported the Biology Café as being helpful (94% of those who visited in FA 23). Most students who visited reported that it helped them feel more prepared for class and exams (52% in SU 24, 65% in SP 24). In general, students reported positive

interactions with the peer facilitators, with indicating that facilitators presented information well and helped to direct their studying (68% in SP 24, 69% in SU 24)

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Undergraduate Views of the Nature of Mathematics

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For centuries, people have been thinking about deep, philosophical questions about the nature of mathematics (NOM), and many philosophies of NOM have emerged over time. One prominent philosophy, *Platonism*, views mathematics as being about eternal, nonphysical, abstract objects that exist external to the mind (Linnebo, 2018). Moreover, NOM is significant for mathematics education because, according to Ernest (1989), 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 one's underlying view of NOM (Ernest, 1989).

Although there is much theoretical literature on the historical philosophies of NOM (e.g., Ernest, 1985; Hersh, 1997; Lerman, 1990; Snapper, 1979) and some empirical studies on student and teacher views of NOM (e.g., Beswick, 2012; Mura, 1993; Raymond, 1997; Szydlik, 2013), there may not be enough empirical research to paint a *comprehensive* picture of the different philosophies of NOM held by actual mathematics students and instructors. This is because most empirical studies either focus on one specific type of participant (e.g., Beswick, 2012; Szydlik, 2013; Wood et al., 1991; Zazkis, 2015), or they use a limited NOM framework to categorize findings (Bentley, 2018; Beswick, 2012; Raymond, 1997; Viholainen et al., 2014).

The significance of my research on NOM is due to its continuation of the work of previous researchers that also addresses the limitations mentioned above. Ultimately, I am interested in exploring the views of both university students and university instructors using a comprehensive, multidimensional framework of NOM. The current study acts as a pilot study for this broader project, considering only the views of undergraduate students using a three-dimensional framework. The first two dimensions, measuring Platonism, are *externality* (whether one views mathematics as being external/discovered or internal/created), and *abstractness* (whether one views abstract mathematical objects as being real or not). The third dimension is *conceptualism* (whether one views mathematics as being more about concepts or procedures). I consider the following research questions guiding my study:

1. For those who perceive mathematics as existing external to minds, do they also tend to hold it exists in an abstract realm?
2. For those who perceive mathematics as existing external to minds, do they also tend to view doing mathematics as ultimately about symbols or something beyond symbols?
3. Do those who have an interest in the topic of NOM show patterns in how they view NOM?

Methodology

Participants included 65 undergraduate students enrolled in various mathematics courses at a public research university in the Southeast United States. Participants completed a survey consisting of five demographic questions followed by twelve Likert scale questions about NOM. Of the twelve NOM questions, there are four questions measuring each of the following three dimensions:

1. Dimension A (Externality): Whether mathematics exists internal or external to minds.
2. Dimension B (Abstractness): Whether mathematics exists solely in physical reality, or beyond physical reality in an abstract realm.
3. Dimension C (Conceptualism): Whether the doing of mathematics is ultimately about symbol manipulation or concepts beyond the symbols.

To establish construct validity of the survey prior to implementation, cognitive interviews were conducted with six participants. After each interview, survey questions were changed as needed when interviewees found a question confusing for the construct it intended to measure. Referencing the amount of needed change for each question, there is evidence of strong validity for Dimension A, moderate validity for Dimension C, and weak validity for Dimension B—whose items were changed frequently because of variation in participants' interpretations of the meaning of terms related to *abstractness*.

After all six cognitive interviews were completed, the final survey was administered to 65 university students enrolled in Calculus I (n=9), Calculus III (n=11), Mathematics for Elementary Teachers (n=38), or Abstract Algebra (n=7) courses. Latent Profile Analysis was conducted to reveal clusters of groups who answered the survey similarly (classes). Patterns in the Profile Analysis provide evidence for answers to the research questions.

Findings

Latent Profile Analysis sorted participants into classes to categorize similar groups of participants' views of NOM based on survey results. We found the 3-class case to be the most revealing, and we label the groups Platonists, Centrists, and Non-Platonists. In the 2-class case, the Centrists and Non-Platonists *almost* wholly merge into a single category. In the 4-class case, only two participants are included in the fourth class.

The Platonist (n=21) class has the highest average score in all three NOM dimensions in addition to the highest self-reported interest in the topic of NOM. Centrists (n=27) score in the middle on all three NOM dimensions, indicating uncertainty or agnosticism in their views. They also have the lowest interest in NOM. Non-Platonists (n=17) have more mind-dependent and procedural/symbolic views of NOM. Like the Centrist class, the Non-Platonist class also has a lower interest in NOM.

Regarding research question 1, there appears to be some evidence supporting the notion that those who perceive mathematics as existing external to minds also hold it exists in an abstract realm. Due to the difficulty establishing validity for dimension B, we conclude this result is ultimately inconclusive. Regarding research question 2, those who view mathematics as existing external to minds tend to view mathematics as existing beyond the symbols, and those who view mathematics as existing internal to minds view mathematics as being more about symbol manipulation. Regarding research question 3, participants with higher interest in NOM tend to hold a more Platonist view, whereas those with lower interest in NOM tend to hold a more Centrist or Non-Platonist view.

Discussion

This pilot study serves as a steppingstone to further research on university student and teacher views of NOM. This research is significant for two reasons. First, it broadens the awareness of NOM research, which is currently sparse within the mathematics education field. Second, it builds on existing research towards a larger study involving a more robust, multidimensional framework and a broader diversity of participants. Limitations of this study include its small sample size of 65 and the difficulty in achieving validity for Dimension B about abstractness. In my future study, I plan to include several hundred participants and more framework dimensions—each grounded in the literature to be of both historical and educational significance.

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Navigating Disclosure: How Does Context Affect the Decisions of Neurodivergent STEM Students During Group Work?

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Background

Group work is a frequently used teaching approach in many undergraduate STEM courses (Wilson et al., 2017). As an active-learning practice, group work can support the development of higher-order thinking skills and provide opportunities to develop teamwork skills that will serve students in future classes and careers (Aikens & Kulacki, 2023; Goldsmith et al., 2024; Slavin, 2014; Springer et al., 1999). However, interactions with peers can create stressful situations during group work, especially for students with less-visible marginalized identities (Busch et al., 2023; Cooper & Brownell, 2016; Downing et al., 2020; England et al., 2017). One identity that is often non-apparent to peers and instructors is neurodivergence. Today, neurodivergence is an umbrella term for people who identify as having a brain that functions significantly differently from the societal standards of "normal" (Walker, 2014). A variety of diagnoses can be associated with neurodivergence, including but not limited to autism, ADHD, specific learning disabilities, or mental health disabilities, such as depression, anxiety, and PTSD. Neurodivergent STEM students report that group work can be especially difficult in certain situations (Gin et al., 2020; James et al., 2020; McGrath & Hughes, 2018; Nieminen & Pesonen, 2022; Pfeifer et al., 2023). For example, neurodivergent STEM students may feel increased stress in group work when tasks are unstructured and when students are assigned a particular role in the group without their input or discussion of their access needs to complete required tasks (Pfeifer et al., 2023; Salvatore et al., in press). Being placed in these types of group work situations may force students to disclose or reveal their neurodivergence to their peers. Yet, there is little known about how neurodivergent STEM students navigate these types of "disclosure experiences" during group work. Thus, the research questions guiding this study are:

1. What features of group work and STEM courses affect how neurodivergent STEM students reveal or conceal to their peers and instructors?
2. What strategies do neurodivergent STEM students use to reveal their neurodivergence or aspects of their neurodivergence to their peers during group work?
3. What recommendations do neurodivergent STEM students have for instructors using group work in their courses?

We address our guiding research questions using theoretical insights from four complementary theoretical frameworks that address key foci of the research questions: individual and contextual factors affecting disclosure (Greene, 2009; Li & Lee, 2023), disability identity (Santuzzi & Waltz, 2016), and the communication strategies individuals may use to reveal stigmatized information about themselves (Zhang et al., 2021).

Significance of the Research

Less than 25% of neurodivergent undergraduates will formally register and use academic accommodations in college (Newman et al., 2019). Moreover, most accommodations provided to students were not created for use within active-learning STEM courses (Gin et al., 2020). Because existing accommodations may be insufficient in most group work situations, there is a real need to understand the experiences of neurodivergent STEM undergraduates during group and how they navigate inherent "disclosure events." A deeper understanding of student experiences will help instructors design group work activities to better meet the needs of neurodivergent students.

Data Collection and Analysis

Semi-structured interviews were conducted with 24 neurodivergent STEM majors from seven institutions, recruited by sharing information about the study with university disability service offices. An example interview question was: "Have you ever told other students in a group that you were a [self-described identity related to neurodivergence]? If yes, what was the experience like telling them?" To analyze the data, we formed a team made up of chemistry and biology education researchers at Thomas Jefferson University and the University of Mississippi. Our team iteratively developed a codebook with inductive and deductive codes and used standard qualitative approaches and coding to consensus to analyze the data.

Summary of Findings

Our emergent findings show that the norms of group work in college courses and the norms within STEM majors affect participants' perceived need to disclose to their peers during group work. We define norms as accepted behaviors within a particular social setting. A participant with the pseudonym Orchid shared an example quote illustrating how norms influence disclosure decisions.

> You're not given any time to get to know your group members before you have to jump into labs and projects. So, there's not like any designated time to sit down and be like, "Hey, I have a communication disability [referring to how they view their neurodivergence].

Participants described engaging in a variety of strategies to share information about their neurotypes with their peers. For example, participants "test the waters" by talking about specific personal traits that they associate with being neurodivergent to let peers know of their identities without naming specific neurotypes or diagnoses.

Our findings also suggest ways that STEM instructors can foster a more welcoming climate for neurodivergent undergraduates during group work. Patchy shared, “I feel like one thing that could help a lot is like instructors explaining potential ways to divide the workload. I've noticed that no instructor really does that, but I feel like it would make a big difference.” Based on our emergent findings, we are in the process of generating a conceptual model of the factors that influence how neurodivergent STEM undergraduates navigate disclosure experiences during group work.

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Measurement View Reasoning: How do Preservice Teachers Use Representational Approaches to Think About Fraction Division?

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Study Background and Significance

Students struggle to understand fraction concepts, especially reasoning with fraction-as-measure approaches (Yeo & Webel, 2024). Fraction-as-measure, hereafter called the measurement view, involves the contextual action of repeated subtraction in fraction division modeling. In this presentation, we provide results from a pilot study on how preservice teachers in a mathematics content course reasoned about a fraction division task that requires a measurement view conception using a representational approach. We define representational approaches as examining mathematical concepts through various lenses that allow students to explain, interpret, communicate, and discuss their mathematical thinking (NCTM, 2000/2014). This study is important because preservice teachers need a deeper and connected understanding of representational approaches in teaching fractions to help children learn productively (Goldin & Shteingold, 2001; Nielsen & Bostic, 2018). Children's productive learning of fraction concepts here means helping them model their thinking using appropriate mathematical representation to solve problems (Dreher & Kuntze, 2015; Fennell & Rowan, 2001; Nielsen & Bostic, 2018).

Theoretical Framework and Research Question

This presentation utilizes the theoretical constructs of *concept image* (Tall & Vinner, 1981) and the *Specialized Content Knowledge (SCK) Progression framework* (Bair & Rich, 2011). Tall and Vinner define concept image as "the total cognitive structure associated with the concept, which includes all the mental pictures and associated properties and processes" (Tall & Vinner, 1981; p. 152). In particular, Vinner (1991) argues that an individual's concept image "can be a visual representation of the concept in the case the concept has visual representations; it also can be a collection of impressions or experiences" (p. 68). With this concept image definition, a representation in this study is defined as a preservice teacher's model of a mathematical concept that denotes their explicit mathematical reasoning. At the analytical level, the SCK progression framework evaluates the preservice teachers' mathematical conceptions, connections, and notions of fraction division that require the measurement view of reasoning. We delimited our analysis to focus on the second component in the SCK progression framework, which describes preservice teachers' ability to use multiple representations to explain their work, justify their reasoning, and make connections. This component of the framework provided a fine-grained process for coding the preservice teachers' knowledge and conceptions using a five-level progression of indicators which include entry (Level 0), emerging (Level 1), developing (Level 2), maturing (Level 3), and deep and connected mathematical knowledge for teaching (Level 4). The SCK framework explains preservice teachers' descriptive nature of their concept image at those five levels of their fraction knowledge and conceptions. The research question investigated in this study is: *How can mathematics teacher educators utilize the SCK Progression framework to characterize preservice teachers' use of representations while learning the measurement view of fraction division?*

Data Collection, Analysis, and Results

This study collected data from 18 preservice teachers enrolled in a content mathematics course at a public university in the southeastern United States. We collected preservice teachers' written responses to the fraction division task that requires a measurement view conception. Regarding the analysis, we used the second component of the SCK progression framework with the five-level progression described earlier to examine preservice teachers' representational approaches to reasoning about a measurement view of fraction division tasks.

Our results showed that students' concept images for fraction division consisted of their ability to model the task with visual representation and connect with the measurement view. For example, Kelly's concept image of fraction division conformed highly to the measurement view conception of fraction division. The results demonstrated that students' concept images about their explanations and interpretations of measurement view of fraction division are more connected to the type of representation (model) used. Emily provided an inappropriate model of 1 ¾ ÷ ½ =? leading to the interpretation of dividing *in half* instead of dividing *by one-half*.

Implications and Conclusion

Preservice teachers' ability to reason about fraction division through the measurement view using appropriate representations strongly indicates their conceptual understanding. Fraction division task modeling using the measurement view allows preservice teachers to develop essential notions that can be connected to other concepts. This study's results indicate that the SCK progression framework shows promise for providing mathematics teacher educators with a useful tool for analyzing, interpreting, and assessing teachers' progress in gaining a conceptual understanding of a broad range of mathematical concepts.

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Exploring the Association Between Communicating About Spectral Data and Acute Awareness of Stigma Attached to One's Gender Among Women in Postsecondary Organic Chemistry Courses

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Introduction

Women report that they must conform to masculine behavioral norms to progress in chemistry, with the necessity of adopting such norms pushing them from the field (Grunert and Bodner, 2011; Miller-Friedmann et al., 2018). Advancing gender-based equity within chemistry will thus entail identifying these norms, deconstructing them, and, ultimately, redefining them to be inclusive of all individuals. To support these efforts, this study investigates whether engaging in a traditional nuclear magnetic resonance (NMR) spectra communication task versus a similar task with multiple identity-safe cues differentially impacts introductory-level organic chemistry students' gender stigma consciousness, or the extent to which individuals are acutely aware of stigma attached to their gender.

Research Questions

The study was specifically guided by the following research questions:

1. To what degree is communicating about NMR spectra on a traditional task versus a task with identity-safe cues associated with greater gender stigma consciousness for women in postsecondary organic chemistry courses?
2. To what degree is gender stigma consciousness associated with women's performance or confidence when communicating about NMR spectra in postsecondary organic chemistry courses?

Methods and Timeline

Undergraduates (n = 543) enrolled in Organic Chemistry II at a large university in the southeastern United States in Fall 2021 and Spring 2022 completed an online NMR communication task followed by a version of the Social Identities and Attitudes Scale (SIAS) modified for use in chemistry learning environments (i.e., the SIAS-Chem). Participants were randomly assigned to one of two prompt groups prior to task completion: one group was told the task evaluates their NMR communication ability, and the other group was told the task was nonevaluative and used to understand the different ways people communicate. Data were collected using Qualtrics.

Data Analysis and Results

To address the research questions, data were analyzed via confirmatory factor analysis (CFA), measurement invariance testing, and regression analysis. Results from CFA and measurement invariance testing provide psychometric evidence of the SIAS-Chem's general functionality and measurement invariance across prompt groups, providing preliminary support for its use in identifying chemistry practices that are potentially exclusionary of women. Further, results from the regression analysis suggest that women who were told the task evaluates NMR communication ability reported greater gender stigma consciousness on the SIAS-Chem compared to women who were told the task was non-evaluative, while there is no evidence of men scoring differently across prompts. Gender stigma consciousness was also associated with confidence during task completion among women who were told the task was non-evaluative.

Conclusion

Results from this investigation suggest that communicating about NMR spectra on a traditional task versus a task with identity-safe cues is associated with greater gender stigma consciousness for women in postsecondary organic chemistry courses, meaning that norms surrounding this disciplinary practice may be exclusionary of women. Moreover, these findings also suggests that the incorporation of identity-safe cues surrounding this practice functions to reduce women's gender stigma consciousness and, in turn, make this practice more inclusive in instructional contexts. Findings have implications for the design of equitable assessments and instruction on NMR spectroscopy and future research on communication styles in chemistry.

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Undergraduate Students' Nature of Mathematics in an Introduction to Proof Course

Jordan Kirby
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What is mathematics? This question, and the study of the nature of mathematics in general, are of interest to many mathematicians. However, many universities, including my own university, do not offer a class dedicated to answering any aspect of the nature of mathematics. Reflecting on the nature of mathematics is important both for personal development as a practicing mathematician (i.e., Hersh, 1998; Lakatos, 1976), as well as for the mathematics concepts itself (i.e., Ernest, 1985; Lakoff & Nunez, 2000). Although in the science community documents such as Vision and Change in Biology education encourage students to reflect on the nature of science at an early age, reflection on the nature of mathematics is lacking even throughout an undergraduate education.

Transition to proof courses offer an excellent time to have students directly reflect on the nature of mathematics due to the seemingly stark contrast of course content between lower division courses such as calculus, and upper division courses involving proof. Boyle and colleagues (2015) noted a transition to proof course may be the first time students are asked to become creators of mathematics rather than just reproduce what they have seen. The need for implicit reflection on the nature of mathematics led to the current study where I pose the following research question: How do students in a transition to proof course view the nature of mathematics?

Significance

This research intends to first gather insight into how early career mathematics majors understand the role and purpose of mathematics as it changes from procedural to a creation focus with proof. Findings of this study will inform future work on task selection for proof classes, as well as determine if there is a need for the introduction of proof or other abstract concepts earlier in a mathematics curriculum to create an easier transition for students.

Methods

Students in a transition to proof course at a small public university in the southeastern United States were asked multiple times throughout the semester to answer the prompt, "In your own words, what is mathematics?" Throughout the semester, the question was repeated, with additional parts including, "If your answer has changed from the start of the semester, what has changed your opinion? Was there anything specific done in the class to change your opinion?" Data collection is still ongoing as of the writing of this submission; however, the question will be asked one final time at the conclusion of the Fall 2024 semester in preparation for the conference. In addition to these questions, multiple homework assignments throughout the semester asked students to reflect on the differences between this course and the other courses taken in their mathematics careers.

Participants

Ten students were enrolled in the transition to proof course. The course was taught primarily as a flipped classroom with students completing homework assignments introducing them to ideas to be covered in more detail during the following class periods. Class periods typically included group work developing conceptions of a proof and following the course notes from Taylor (2007). Additionally, students completed a proof rubric assignment described by Boyle et al., (2015). Nine of the ten students were mathematics majors, with the tenth student being a computer science major with a mathematics minor. Eight of the ten students had taken a discrete mathematics course in the previous semester with a focus on logic and introduction to proof.

Analysis

Answers to questions and homework assignments were coded to find common themes in student answers. As of the writing of this manuscript, the prompt, “What is mathematics” has been given to students twice, and one homework assignment has asked students to reflect on their previous mathematics experiences. There are 2 more planned homework assignments and one more answer to the prompt to be taken in with the data.

Results

Preliminary results indicate an overwhelming majority of students began the semester viewing the nature of mathematics as a “toolbox” to be used for either mathematics itself (i.e., solving problems, answering word problems), or as a tool to be used for other disciplines. As the semester has progressed, the second batch of student responses has started to change slightly away from the toolbox representation of mathematics to many including that mathematics seeks to instead validate and answer questions that arise through studying.

Discussion

Findings from this study are intended to be used to encourage instructors of proof classes to consider any activity that is commonly mentioned in the students’ responses to the prompt, “What is mathematics?” Further, the overwhelming majority of mathematics majors entering this course with a conception of mathematics as a “toolbox” warrants future research to investigate how our instruction of mathematics from K-16 neglects to teach mathematics for mathematics’ sake, rather for the sake of accomplishing a task in another discipline. I hope to hear from attendees what aspects of the research are most convincing, and what future directions would be interesting to explore as the research continues.

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Developing the Future of Safer MRI Contrast Agents: An Advanced Undergraduate Chemistry Lab Experience

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Functional ligands that bind metal cations are of great interest to the field of chemistry research focused on drug delivery and diagnostic imaging. These complexes find greatest success when the metal center has unpaired electrons and creates a paramagnetic moment for the molecule itself.[1] Gd^{3+} ions contain 7 unpaired electrons in f orbitals and as a result are the most paramagnetic species stable enough for human use.[2] They are therefore prominently featured in compounds used for diagnostic MRI as they can dramatically shorten the T1 and T2 relaxation of water protons in a magnetic field, which is exploited in the weighting of pulse sequence parameters to provide additional contrast in an MR image.[3] However, because of the toxicity of free Gd^{3+} ions, there is a growing volume of research aimed at developing chelates of less toxic metals such as iron or manganese into MR imaging compounds.[4] In a parallel endeavor, we are always working to make the lab experiences for our chemistry students more engaging and relevant by presenting fundamental chemical concepts in the context of their significance to research and the world in general. The synthetic techniques and characterization methods employed by those aiming to make the MRI contrast agents of the future are not out of the reach of upper-level chemistry undergraduates learning inorganic and physical chemistry. Our work makes the most of the unique collaborative research environment at UAB to create a bridge between these two endeavors and show students that their lab project has the potential to make a real impact in the world of medicine.

In terms of the design of MRI contrast agents, it is becoming clear that in addition to the degree of paramagnetic character, the exchange rate of water protons at the metal center is potentially as important in shortening the T1 and T2 relaxation rates.[5] Gd based agents are less likely to maximize this feature due to the intrinsic toxicity of the free ion. Every effort is typically taken to increase the stability of the compound toward leaching of the Gd^{3+} ion with safety in mind, but at the cost of potentially increased efficacy.[6,7] Since there are several endogenous processes in the body that regulate the concentration of, and even rely on, manganese ions,[8,9] the potential for even minor dissociation that would render a Gd^{3+} based agent unsafe is of lesser concern for Mn based agents. In fact, reports are emerging on Mn chelators with relaxivity values that are competitive with well-known standards such as Gd-DOTA,[8] owing in part to the availability of coordination sites at the manganese ion. These concepts are straightforward, but due to the rapid rise and dominance of gadolinium contrast agents over recent years, research on these manganese contrast agents is still new and has great potential for innovation and discovery.

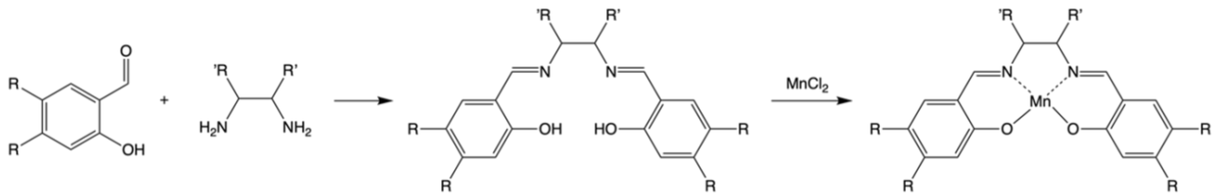

Figure 1. Generalized synthesis of the Salen -type ligand. It is a simple one -step process to carry out the initial condensation, and employing a series of precursors with different R -group substitutions can quickly generate a library of compounds

Our methodology and preliminary results: initial stages open the door for novel work

Our work features the synthesis and characterization of several manganese chelators based on the well-known Salen ligand[10] (Figure 1), a class of metal binding species that typically feature a tetradentate binding motif based on oxide and Schiff base chelation points. The original Salen ligand that all derivatives inherit their name from can be synthesized from salicylaldehyde and ethylenediamine and a generalized derivate scheme is shown below. It is apparent from the structure of the Salen ligand that simple substituent replacement and modification at the aromatic carbons of salicylaldehyde and the aliphatic carbons of ethylene diamine can result in a variety of Salen-type ligands in which the substituents may aid or hinder the overall paramagnetic moment, exchange of solvent molecules at one or more binding sites of the bound Mn^{2+} cation, and stability of the complex toward exchange of the metal.

To explore these effects, students synthesize Salen-type compounds in week one of the project and perform metalation with manganese and typical structural characterizations (UV-vis and NMR spectroscopy) in week two. Derivatives that are water soluble (an obvious prerequisite for a potential MRI contrast agent) are carried forward to Evans method experiments to evaluate the apparent number of unpaired electrons, and therefore the spin state, at the manganese center during week 3. Derivatives identified as high-spin (having 5 unpaired electrons on Mn) are further characterized via custom-built pulse sequences on one of our department's NMR spectrometers during week 4 to evaluate the T1 relaxivity of their compounds via inversion recovery (figure 2). Finally, students can sign up for an optional extension to the study where they take their best candidates to a 3T MRI at the UAB Civitan International Neuroimaging Laboratory and develop the MRI pulse sequence used to collect image data and compare the inversion recovery T1 map to their NMR results.

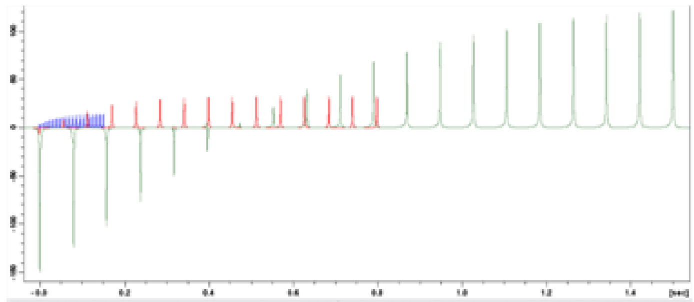

Figure 2. The green, red, and blue compound spectra represent respective series of inversion recovery experiments at 0.1 mM, 0.5 mM, and 1.0 mM Salen concentration in H_2O. The dramatic shortening of the inversion recovery shows the effect of the complex on the relaxation of the solvent

Future direction: evaluation against the industry standard and computational studies

Based on feedback so far, students find the topic exciting and engaging, and we have seen some promising results in terms of the relaxivity of several student compounds. Future directions include moving to analysis in blood plasma to compare the performance of their compounds to an industry standard such as ProHance and building in a basic computational series on DFT calculations to provide more information on the expected geometry of the complexes. The DFT series will be particularly useful in visualizing the "axial" binding sites of the ligands and the interaction of solvent and ionic ligands with the metal center.

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

Emily McDonald
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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 turn, 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.

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 classroom?

Methodology and Timeline:

The study was conducted over 9 weeks 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 engagement and motivation of students.

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.

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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Beg, Borrow, and Steal - Adapting Existing Games for Chemistry Courses

David Crisostomo (Auburn University)

While gamification has been shown to improve engagement and motivation of students, incorporating and creating games for the classroom can be challenging. Furthermore, playing new games adds to the cognitive load of learning the game rules in addition to learning the actual material. By utilizing existing games as a framework, instructors can reduce the difficulty of developing new games and activities. Additionally, students' familiarity with games in other formats lowers the barriers for engagement to get to the learning more quickly. In this presentation, we will discuss activities inspired and based on the games Hedbandz, Telestrations, and Connections and play through some examples.

Exploring the Impact of Automated Assessments in a Quantitative Methods Course

Raluca Clendenen & Brad Schleben
(Belmont University)

This is a preliminary report on a study investigating the effectiveness of self-grading Excel spreadsheets as a feedback tool in STEM education, particularly focusing on their impact on student learning outcomes, engagement, and satisfaction. By providing students with instant feedback on assignments, these self-grading spreadsheets are intended to enhance students' understanding and mastery of mathematical concepts. The study gathers student feedback to explore their perceptions of how these tools influence their learning process, confidence, and comprehension in mathematical contexts. Additionally, this research identifies and addresses the challenges of designing and implementing self-grading assignments, offering insights into best practices for integrating technology-driven feedback tools in STEM education. Preliminary findings suggest that self-grading spreadsheets may serve as a valuable resource in promoting active learning, with implications for improving student engagement and satisfaction.

Comparison of Student Reflections on their Undergraduate Research Experiences in Chemistry and Biology Introduction

Chazzidy Harper
(Kennesaw State University)

"A mentored investigation or creative inquiry conducted by undergraduates that seeks to make a scholarly or artistic contribution to knowledge" is the definition of undergraduate research (UR) given by the Council on Undergraduate Research (CUR; Council on Undergraduate Research, 2024). According to Scogin et al. (2023), undergraduate research emphasizes defining, carrying out, and rating student research experiences. According to Linn (2015), undergraduate research can help students get better at describing ideas scientifically, attributing scientific goals to experiments, and identifying originality in both research and instruction. Seminal contributions have been made by Adebisi (2022), asserting that undergraduate research is regarded by many undergraduate students and faculty members to be a significant part of providing a high-quality academic experience.

Bhattacharyya et al. (2020) also highlight how important practical research experiences are for improving student learning outcomes, critical thinking ability, and practical problem-solving skills. Furthermore, Picardo and Sabourin (2018) presents critical perspectives from undergraduate research participants, highlighting their experiences, acquired knowledge, and areas for growth, such as ethical conduct, competence in scientific writing, and effective oral communication.

The landscape of STEM education is continually evolving, with undergraduate research becoming increasingly crucial in cultivating deep learning and fostering innovation. Shapiro et al. (2015) suggests prior research previously dominated by the traditional apprentice Model; the sphere of undergraduate research has experienced a revitalizing shift with the advent of Course-based Undergraduate Research Experiences (CUREs). This transformation is part of a wider pedagogical shift aimed at broadening the accessibility of research opportunities to a more diverse array of students. While both models provide vital avenues for the development of skills and scientific exploration, they each present unique frameworks, advantages, and challenges that significantly affect student outcomes.

This novel analysis of critical reflections seeks to explore two predominant models—the Apprentice and CURE—by examining their unique features, impacts, and student perspectives. Through a comparative analysis grounded in student experiences and educational outcomes, the project aims to illuminate effective strategies for integrating research into undergraduate STEM education, enhancing both students' educational journeys and advancing scientific understanding.

Research Question

1. How do KSU students' reflections on their undergraduate research experiences in chemistry and biology differ based on the format of the experience (apprentice model vs CURE)?

2. What are common characteristics of courses, students and faculty involved in undergraduate research experiences at KSU in chemistry and biology?

Methodology

There were 300 critical reflections used in this study design from a variety of STEM disciplines and colleges, but this study analyzes 118 critical reflections from Kennesaw State University's College of Science and Mathematics, focusing on chemistry and biology research experiences. Of these, 82 reflections are from the apprentice model and 36 from the CURE model, representing 2 CURE sections and 31 apprentice model sections over both chemistry and biology. Using a phenomenographical approach, the study qualitatively explores students' experiences in the research experiences.

Data Analysis

Undergraduate students' critical reflections from the 2022-2023 academic year were analyzed to capture diverse research experiences and identify overarching patterns. Using NVivo for coding, the analysis applied a mixed coding approach: initial inductive coding based on four student learning outcomes (educational value, connections to coursework, integrated problem-solving, and values growth) adopted as part of the Quality Enhancement Plan at our university (It's About Engagement, n.d.), followed by thematic coding to identify sub-themes. To ensure inter-rater reliability, two trained coders reviewed 23% of the 300 reflections, achieving 90% agreement.

Results and Conclusion

The study demonstrates that both the CURE and apprentice models significantly enhance students' problem-solving abilities, technical skills, and research preparedness through structured hands-on experiences. This claim is supported by evidence that shows 100% of CURE participants and 75% of apprentice participants faced research-related challenges, with high percentages adapting to overcome them. Additionally, the data indicates a growth in skills and professional attitudes, with students in both groups improving in areas like teamwork, adaptability, and communication. This evidence supports the idea that structured research experiences provide crucial real-world insights, which not only strengthen students' academic foundations but also enhance their career readiness by fostering resilience and interdisciplinary learning skills.

In sum, the study underscores how both CURE and apprentice experiences contribute to a more comprehensive understanding of scientific inquiry and improve readiness for professional scientific careers, proving that hands-on research fosters critical thinking, adaptability, and collaborative skills essential for success in the field.

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Building an Immersive and Inclusive Organic Chemistry Learning Experience

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Visualizing the transition from 2D molecular structures to 3D representations presents a significant challenge for students, especially in organic chemistry. To support students in mastering this skill, we developed a web-based virtual reality (WebVR) eLearning activity focused on R and S stereochemistry. This 50-minute, scaffolded, and gamified experience—complete with badges and formative assessments—helps students connect 2D structural representations with rotating 3D molecules through an immersive learning environment. Created in collaboration with Auburn Online, this novel tool enables students to better visualize and manipulate molecular models.

Piloted with over 300 organic chemistry students at Auburn University in Fall 2022, 80 to 90 percent of participants reported improved ability to visualize molecules and correctly label stereocenters. The feedback gathered was instrumental in refining the activity's interface, and the project is now expanding to include substitution and elimination reactions.

In addition to enhancing spatial thinking, the activity integrates diverse representations of scientists to create an inclusive learning experience that resonates with a wide range of students. This session will not only offer insights into the development of the WebVR activity but also provide attendees with hands-on interaction with the 3D modeling tools, highlighting the potential of WebVR to enhance both STEM education and inclusivity.

Undergraduate Student Conceptions & Sources of Knowledge of Reproduction & Pregnancy

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Study Context: In light of the US Supreme Court's overturning of Roe v. Wade and the emergence of medically unfounded laws, understanding undergraduate (UG) students' knowledge on reproduction is vital for future informed decision-making (Kekatos et al., 2022; Nguyen & Kenmore, 2022). Undergraduate (UG) students represent the future voters & leaders in our country. We believe it is important to understand their knowledge of this aspect of physiology given the importance of reproductive freedoms & their connection to medical knowledge. Currently, there is little information about these topics reported in the literature. We surveyed UG students to gather their understanding of reproductive knowledge relevant to abortion & the source of this knowledge using the JAMA Benchmarks (Silberg et al., 1997) as our initial theoretical framework.

Research Design: We asked the following research questions: 1 – What relevant knowledge do UG students have concerning reproductive physiology related to pregnancy & embryonic development? 2 – What sources of knowledge do UG students disclose about these topics?

A survey was designed to assess UG student knowledge of reproduction & pregnancy-related topics centering around the topics of discussion of the A&P Professor Podcast, episode 118, including definitions & timeline of pregnancy, heart development, pain sensation, & age of viability (Patton, 2022). Five open-ended content questions assessed student knowledge of these topics. Each content question was followed by the open-ended question of "How do you know this information? Where did you learn this?" The use of open-ended questions allowed participants freedom to provide their own perspective, strengthening theoretical, pragmatic, & procedural validity & process reliability of the work (Walther et al., 2013). The survey was distributed on social media by members of the research team. In total, 72 responses were collected between July 2022&February 2023 & then analyzed.

Analyses & Interpretations: Question responses were analyzed using multiple rounds of coding, as described by Saldana (2016). First, research team members sought 'answers' for each content question using medical journals & textbooks. Next, all responses to that content question were reviewed by the researcher who compiled 'correct' answers using an open coding process. Responses were scored for correctness & a code was also assigned. Sources of knowledge responses were scored by a single researcher using the JAMA Benchmarks as an initial framework. The initial codebook for each question was presented to the full research team for review & critique. This was followed by code mapping for each survey question & a second round of coding. All rounds of coding used the constant comparative method & changes to codes or code assignment were discussed among the team to consensus. All coding choices were entered into a spreadsheet for ease of comparing the relationship between answer correctness & source of knowledge.

Overall, 38 correct answers within 360 content question responses (10.6%) were provided by participants. Two content questions had no correct answers provided. Participants had various misconceptions about the definition of pregnancy, the timeline of pregnancy, & the developmental processes & timing within the human embryo/ fetus. These ranged from incorrect timelines (both too short & too long) to factually incorrect information. The sources of knowledge reported were separated into 6 codes – peer-reviewed source/ content expert (10%), formal source without clear connection to a content expert (14.4%), informal source/ popular culture (9.4%), personal experience (0.5%), personal knowledge/ opinion (19.4%), & no source (46.1%). However, only six correct answers were claimed to be known because of knowledge conveyed by a content expert or peer reviewed source (15.8% of correct answers).

Contribution: No recent work has sought to describe UG student knowledge & misconceptions of reproductive physiology related to abortion access. This study begins to address this gap in our knowledge. In the present study, only one of the content questions is related to information specifically mentioned in the current HAPS Student Module Learning Outcomes for Anatomy\ Physiology or Physiology (*HAPS Learning Goals*, 2020). Therefore, it might not be surprising that so few students were able to provide a correct answer & that they didn't cite a content expert or peer-reviewed source as the source of this knowledge. However, this presents a problem. If we intend to educate the next generation of voters & leaders, how are we providing them relevant knowledge to the current events of our day? This study underscores the need for educational adjustments to enhance UG understanding of reproductive physiology in the context of contemporary issues. Our findings should prompt a reevaluation of educational content to better equip future leaders with accurate and relevant knowledge.

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Could Exam Retake Policies Serve as an Avenue for Advancing Diversity, Equity, and Inclusion in Chemistry Education?

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Chemistry education is important for developing next generation of scientists. Traditional exam focused assessments can unintentionally disadvantage students from underrepresented backgrounds. This talk argues that allowing limited exam retakes can address inequities while upholding high academic standards.

Strict no-retake policy assumes a one-size-fits-all learning model and fails to recognize the diverse circumstances students face. Factors like first generation status, family responsibilities, language barriers and poor performance in formative assessments can impair exam performances. Retake opportunities give students a chance to demonstrate their learning after identifying and addressing weaknesses. When structured to prioritize learning over grades, retakes can cultivate a growth mindset and a sense of belonging for all.

Pilot data from Tennessee State University and Nashville State Community College shows that when allowed one retake per semester, D, and F earning rates decrease for most students, bringing their outcomes at a higher level.

Chemistry educators could consider implementing limited exam retake policy along with formative assessment reforms. Pairing accountability with compassion could foster inclusion while still maintaining the integrity of chemistry curricula. This framework respects diverse learners and has the potential to advance diversity, equity, and student success in STEM higher education.

Ongoing Findings from a Systematic Review of the Identity Negotiations of Doctoral Students in the Natural Sciences

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Introduction

One of the main purposes of doctoral education in the natural sciences is to prepare doctoral students to become independent scientists who are recognized members of their disciplinary communities (National Academies of Sciences, 2018). To achieve this, doctoral students must cultivate and build their professional scientist identities during their training (Hancock & Walsh, 2016). Though this is important, doctoral students, especially those from historically marginalized groups, often face misrecognition from members of their disciplinary community (Avraamidou, 2020, 2022; Castro & Collins, 2021; A. Gonsalves, 2018; A. J. Gonsalves, 2014; Sugiyama et al., 2024). This is problematic, as misrecognition can jeopardize doctoral students' persistence in their education or even limit their ability to access resources and opportunities needed to advance their careers. Many doctoral students engage in "identity negotiations" to maintain their identities as scientists. Studies in the fields of education and other social sciences have documented certain behaviors and processes that students use when engaging in identity negotiations. Examples of behaviors associated with identity negotiations include women in physics graduate programs dressing androgynously to better align with the masculine climate of their department (A. J. Gonsalves, 2014) or doctoral students from historically marginalized groups seeking community with others to affirm both their racial and scientist identities (Sugiyama et al., 2024).

Though various identity negotiation behaviors have been described, many of these studies do not provide an explicit definition of what identity negotiations are. Additionally, studies often use different but related terminology to investigate the same phenomenon. For example, the terms "identity flexing," "identity calculus," and "identity work", are terms that appear within the literature and seem to mean the same thing as "identity negotiation." Yet it remains unclear whether, and to what extent, the findings of these studies coalesce. Often, these studies use similar but different identity theories as their guiding frameworks and are found within disparate bodies of literature (i.e., science education journals versus organizational psychology journals). Given the murky state of identity negotiation and related research, there is a need for theory that can clearly define what identity negotiations are and integrate various fields' research findings into a coherent body (Cumming et al., 2023). To address this need, we are conducting a systematic review of the literature related to doctoral student identity negotiations, to help develop a more robust conceptual framework. A systematic review is a specialized literature review that uses transparent and replicable methods to identify relevant research, synthesize findings and inconsistencies, and develop theory for a given area of research (Cumming et al., 2023; Siddaway et al., 2019).

The following research questions broadly guide our study:

1. *How are identity negotiations and related constructs defined within the literature of doctoral students' identities in science?*
2. *What theories or frameworks are used in these publications?*

Methods and Results

To conduct the systematic review, our research team consulted with institutional research librarians to construct a search string informed by identity negotiation literature. The search string contained terms meant to target literature published between 2000 and 2024 that centered doctoral students' experiences, had research contexts in the natural sciences, and studied identity negotiations or related concepts as their phenomenon of interest. The search was conducted in September 2024 in eight databases within the fields of science education, higher education, psychology, organizational psychology, and business. We then used a list of exclusion/inclusion criteria to screen the library in COVIDENCE, a systematic review software, to determine what literature was relevant for data collection and analysis (Cumming et al., 2023). Once irrelevant publications were removed, we extracted relevant information from each remaining publication. For example, we extracted characteristics of each publication (e.g., year published, methods used, focal identities investigated, definitions of identity negotiation (if any), theories used in the study, and key findings of each study). Finally, we synthesized our findings to generate a typology of identity negotiation definitions, and the theories used in each study. We used consensus coding throughout the literature screening, extraction, and synthesis phases. We present our preliminary findings of our systematic review. There are a variety of theories and frameworks that studies have used including intersectionality, identity work, science identity, and identity trajectories. Though studies provided examples of how participants had negotiated features of their identities, few studies provided a clear and explicit definition of what identity negotiations are. Finally, studies in physics contexts often considered gender as a focal identity in their work, and studies that considered broader STEM contexts often considered participants' racial identities as a focal identity.

Significance of the Research and Conclusion

Current literature has yet to clearly define or comprehensively characterize the identity negotiations doctoral students in the natural sciences use to develop their professional identities as scientists. Additionally, different fields often study the same phenomenon using different but related terminology and theories. The lack of clear conceptualization and the disparate bodies of knowledge make it difficult to know what constitutes identity negotiations and how findings from different fields relate. We seek to provide clarity through our ongoing work to develop a conceptual framework of the identity negotiations of doctoral students in the natural sciences. The resulting conceptual framework will be of use for future investigations of identity negotiations across the natural sciences.

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Mathematically Minded: A Case Study Exploring a Foundry-Guided Course to Improve STEM Students' Critical Thinking Skills through a Historical Markers Database Activity

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Background Literature

Critical thinking is a skill that is essential for education and life (Reboot Foundation 2020). Interdisciplinary Science Technology Engineering and Mathematics (STEM) students often need to develop critical thinking skills to leverage knowledge from different disciplines that enhance their perspectives on real-world problems. In this sense, critical thinking can help students working in interdisciplinary environments specify information that can lead to new historical and social knowledge necessary to engage in problem solving. In this study, we investigate an approach to understand the pedagogical significance of using the Critical thinking Assessment Test (CAT) Skillset 2 (questions 10-11, 13-15) (Haynes & Stein, 2021) to help develop skills that assist students to make connections to historical and contextual knowledge, specifically in an interdisciplinary Foundry-guided course. The CAT Skillset 2 focuses on problem solving skills and, for this specific course, integrates data analysis using the Historical Markers Database, to help students identify relevant challenges for a Foundry-guided project. Foundry-guided courses use the Renaissance Foundry Model, an innovation-driven learning platform, where student teams develop a prototype of innovative technology that is relevant to addressing a real-world problem anchored in historical and social contexts that make the challenge significant (Arce et al., 2015; Wilson et al., 2024).

Significance

A survey of the public in France and the U.S. conducted by the Reboot Foundation (2020) indicated that 94% of the respondents' support teaching critical thinking skills, with 60% of the respondents reporting that they did not study critical thinking in school. Educators and psychologists worldwide perceive critical thinking as a skill that can be achieved through training (Shaw et al., 2020). In STEM disciplines, where interdisciplinary collaborations are becoming more necessary to addressing complex, ill-structured problems, developing critical thinking skills is ever more relevant and pivotal. The significance of this study therefore lays in the intersection of understanding how the CAT Skillset 2 in an interdisciplinary, Foundry-guided course may help STEM students to enhance their ability to identify specific historical and social contextual cues for their project. In this contribution, we offer an overview of the CAT Skillset 2 activity used in the featured Foundry-guided course, present a descriptive data analysis that was reviewed from the Historical Markers Database, and illustrate a relevant alignment map that depicts how critical thinking skills are integrated into Foundry-guided courses through a focus on the CAT Skillset 2.

Research Question

For this study, we center on the following research question: In what ways can the Critical thinking Assessment Test Skillset 2 (10-15) be leveraged to help STEM students engage in connecting historical and social knowledge using a historical markers database?

Data Analysis Procedure

This contribution features a pedagogical case study that presents the activity used to introduce STEM students to CAT Skillset 2 in a Foundry-guided course. As part of this activity, a descriptive analysis of the Historical Markers Database to analyze regional data that focuses on mathematical-related markers is featured in students' challenge identification lesson. The Historical Markers Database (Pratts, 2024)

> is an online, searchable database, of historical information viewed through the filter of roadside and other permanent outdoor markers, monuments, and plaques. It contains photographs, inscription transcriptions, marker locations, maps, additional information and commentary, and links to more information. Anyone can add new markers to the database and update existing marker pages with new photographs, links, information and commentary. (p. 1)

Descriptive data from this historical marker analysis includes information related to location, historical range, social significance, and shared qualitative information which is beneficial for students to understand and apply the CAT Skillset 2. This analysis is, in turn, aligned to Foundry-guided elements that help students develop critical thinking skills as related to challenge identification. This study is part of a larger critical thinking development strategy that was implemented in a National Science Foundation- National Research Traineeship program. This program is intentionally interdisciplinary in nature and requires the interaction of interdisciplinary, STEM students in a space that focuses on design thinking as defined by the Renaissance Foundry Model (Wilson et al., 2024).

Summary of Findings

This case study provides insight into the alignment between the CAT Skillset 2 and a Foundry-guided course, particularly for the development of critical thinking skills. The presentation of the pedagogical strategies related to this pairing help provide lessons learned regarding how to leverage CAT Skillset 2 to help STEM student in an interdisciplinary course identify relevant historical and social knowledge for Foundry-related activities. In terms of the descriptive analysis, preliminary findings from the Historical Markers database indicate that there are comparable mathematical related markers in the Southeastern region, that focus on specific historical and social contexts. Of those markers, there are implications for the use of critical thinking Skillset 2 for the development of students' use of analytical skills for the purpose of understanding historical and social contexts that relate to mathematical content. Within a Foundry-guided activity, reviewing historical markers, their locations, and their content as part of building interdisciplinary skills as it relates to critical thinking and problem identification is important.

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STEM Graduate Teaching Assistants: Exploring the Relationship Between Autonomy, Discontentment, and Self-Efficacy

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Significance and Literature Review

Due to the prevalence of graduate teaching assistant (GTA) instructors in introductory STEM courses, GTAs have been described as the "first line of defense" for the persistence of undergraduate STEM majors (Nicklow et al., 2007). Through their role as GTAs, graduate students have the potential to impact the education of many undergraduate students (Gardner & Jones, 2011). However, their teaching professional development (TPD) is often undervalued by faculty mentors and departments potentially leading to low quality instruction by these GTAs (Schussler et al., 2015). Many institutions have indicated they offer voluntary TPD programs, where engagement is necessarily limited (Schussler et al., 2015). This begs the question of how we can better understand how and why STEM GTAs engage in TPD and how this engagement impacts their instructional beliefs and practices (Authors et al., 2016). In secondary school contexts, evidence suggests that teachers' engagement in TPD opportunities can be driven by their pedagogical discontentment (dissatisfaction with teaching practices) and self-efficacy (confidence with teaching practices; Southerland et al., 2011). These researchers suggest that instructors who experience pedagogical discontentment and have high teaching self-efficacy may be more likely to engage in TPD and attempt evidence-based instructional practices. Based on this model, we hypothesized that facilitating pedagogical discontentment while supporting GTA self-efficacy might be an effective method for encouraging GTAs to consider engaging in TPD and then engaging in alternative instructional practices. However, instructors, such as GTAs, who have limited teaching autonomy (i.e., they do not define their teaching goals or classroom practices; Dillard et al., 2023; Flaherty et al., 2017; Winters & Matusovich, 2011) may not have the opportunity to develop dissatisfaction to adopt evidence-based teaching practices. Thus, the purpose of the current study was to further understand the relationships between autonomy, pedagogical discontentment, and self-efficacy among GTAs in the STEM disciplines. This study addressed the following **research questions:** 1) How does perceived autonomy, pedagogical discontentment, and self-efficacy differ in GTAs between the STEM disciplines? 2) Are there relationships between the GTAs' perceived autonomy, pedagogical discontentment, and self-efficacy?

Data Analysis Procedures

This study used an explanatory mixed-methods research design (Ivankova et al., 2006; Mills & Gay, 2016) to collect quantitative survey data of GTAs in the biology, geology, chemistry, and mathematics disciplines (n = 50) from a Southeastern United States university. Survey items for autonomy, pedagogical discontentment, and self-efficacy were adapted from the literature as needed (DeChenne et al., 2012; Pearson & Hall, 1993; Southerland et al., 2012). To address research question 1, we ran ANOVAs and post-hoc Tukey HSD tests for multiple comparisons to determine if there was statistical evidence for differences in the means based on the GTAs' discipline. To quantitatively address research question 2, we calculated Pearson correlation coefficients. We used stratified sampling techniques (Mills & Gay, 2016) to identify survey participants with high (1 - 1.75), moderate (1.75 - 3.25), and low (3.25 - 4) perceptions of autonomy for semi-structured interviews to qualitatively address research question 2. We interviewed six participants: three with low levels of autonomy, two with moderate autonomy, and one with high autonomy. Interviews were conducted over Zoom for approximately thirty minutes to an hour. To analyze the interviews, two authors deductively coded the transcripts for the GTAs' perceptions of autonomy, pedagogical discontentment, and self-efficacy, meeting to discuss as needed to reach a consensus. We allowed multiple codes to be applied to data segments to help us understand the relationships between constructs for each GTA.

Summary of Findings

Research Question 1: Differences Among Disciplines

For both pedagogical discontentment and self-efficacy, there were large p-values which does not provide evidence of a difference between the reported perceptions among the GTAs' respective disciplines (discontentment: $F(3, 46) = 0.695$, $p = 0.560$, $\eta^2 = 0.043$; self-efficacy: $F(3, 46) = 2.704$, $p = 0.0563$, $\eta^2 = 0.149$). There was a small p-value for autonomy, which provides evidence of a difference between autonomy levels among the disciplines ($F(3, 46) = 2.581$, $p = 0.0393$, $\eta^2 = 0.177$). Post-hoc Tukey HSD test indicated that the biology GTAs reported lower levels of perceived autonomy while the mathematics GTAs reported higher levels of autonomy. Chemistry and geology GTAs reported similar perceived autonomy levels.

Research Question 2: Relationships Between Constructs

There was evidence of a low, negative correlation ($r_{48} = -0.36$, $p = 0.01$) between pedagogical discontentment and self-efficacy. This finding indicates that the more confident GTAs tend to report lower pedagogical discontentment (i.e., more contentment). There was no evidence of a correlation between autonomy and self-efficacy, as indicated by a high p-value ($r_{48} = 0.11$, $p = 0.45$). There was evidence of a low, positive correlation ($r_{48} = 0.28$, $p = 0.04$) between autonomy and pedagogical discontentment. This finding indicates that GTAs who report lower levels of autonomy tended to report lower contentment (i.e., higher pedagogical discontentment). To better explore these relationships, we also collected qualitative data.

Here, we present the findings from the interviews of Payton (chemistry GTA, low autonomy), George (biology GTA, moderate autonomy), and Ben (mathematics GTA, high autonomy) for the correlation coefficients with low p-values (pedagogical discontentment and self-efficacy; pedagogical discontentment and autonomy). In their interviews, all three participants reported instances of discontentment and contentment with their instructional autonomy. Participants also indicated their interactions with students could impact their self-efficacy. Payton indicated that she was mostly content with her perceived autonomy, once she got comfortable with her lab supervisor, she recognized that she could make decisions and changes based on "what [she] thinks is right for the students." George was content with his autonomy, though he experienced frustrations when the lecture and laboratory content were uncoordinated. George described having high self-efficacy because of his experience as an instructor and could now focus on gaining "a sense of satisfaction" when he felt students were learning. Ben described feeling content with having "a lot of freedom to just teach the way [he] wants to." Ben did, however, experience some discontentment as he liked having freedom but wanted to make sure he "adhered to the certain objectives" covered on the departmental final.

Contribution

This study extends prior work on GTA autonomy (Dillard et al., 2023; Flaherty et al., 2017; Winters & Matusovich, 2011) by finding evidence of GTAs' perceptions of pedagogical discontentment relating to their self-efficacy and autonomy. We also found that biology GTAs tended to report lower autonomy levels than other STEM disciplines in this study. This indicates that TPD programs need to carefully consider GTAs' autonomy to support them within the constraints of their environment. Student interactions with GTAs were an important contributor to their self-efficacy and (dis)contentment. GTAs reported examples of perceived instructional autonomy influencing their (dis)contentment. From this study, it is still unclear how various perceptions of these constructs can influence GTAs to engage in TPD programs (either voluntary or mandated) which are imperative to support GTAs' use of evidence-based teaching practices to support underrepresented students in STEM (Eddy & Hogan, 2014; Theobald et al., 2020).

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Levers and Barriers to Graduate Students Teaching Professional Development (GS TPD): Results from Expert Consensus Using Delphi Methodology

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Overview of background literature & Theoretical Perspectives:

Graduate Teaching Assistants (GTAs), like faculty members, require teaching professional development (TPD) to sharpen their pedagogical skillset for effective undergraduate instruction. This is particularly important given that GTAs teach/lead most, if not all, undergraduate course instruction in STEM–related disciplines (Kurdziel & Libarkin, 2003; Sundberg et al., 2011). In some cases, GTAs take sole instructional responsibilities—as instructors of record—for laboratory and discussion sections (Sundberg et al., 2005) or teach large introductory undergraduate science courses (Kendall & Schussler, 2012). However, GS/GTAs continue to receive less attention across departments and academic units regarding TPD. Despite attempts to ensure holistic preparation of graduate students for their current GTA and future instructional roles (Sandi-Urena, 2011), many GTAs feel "poorly and completely unprepared" for their current undergraduate and/or future academic instructional roles (DeChenne et al., 2012, p.5; Gardner & Jones, 2011; Oleson & Hora, 2014; Reid & Gardner, 2020). In most departments and academic units where GTAs receive any form of training at all, they are mostly inadequate and/or unstructured without a *guiding model* to replicate from and ensure uniformity of practice in similar (other) departments/academic units across colleges and universities, particularly in the U.S. context (Reeves et al., 2016; Spencer & Molina, 2018).

While TPD appears to be inadequate for GS in academic units/departments, departmental characteristics and cultural commitments that *lever* or *barrier* academic units/departments from undertaking these TPDs are unknown, highly understudied, and/or undertheorized in literature. Even more deserving of an exploration regards the lack of a *model or framework* for change that could serve as a guide for undertaking GS TPD across departments, units/Teaching and Learning centers, etc. The lack of a guiding framework/model for GS TPD has birthed these dual effects: a challenge to initiate GS TPD and lack or ubiquity, uniformity, and consistency of some sort in organizing TPD for GTAs across departments and colleges (Reinholz & Andrews, 2024). Thus, literature is dearth with studies that have explored departmental commitments that serve as levers or restraints to GS TPD. In most cases, departments/academic units offer one or two coursework and/or graduate (orientation) seminars in lieu of TPD in its broader sense.

To address this, we examined the *cultural characteristics* and *departmental commitments* that lever and/or restrain GS TPD in academic units/biology departments. Given that the study focuses on identifying the *cultural characteristics and departmental commitments*, it served a great purpose to zoom in on underlying factors of culture in departments/academic units/Teaching & learning Centers/ etc. that serve as levers or hindrances to organizing GS TPD. We define cultural commitments in academic departments as aspects of departmental culture where individuals are engaged with specific beliefs and values, by sharing practices and structures for demonstrating them within their unique departments (Quan et al., 2019).

Theoretical Underpinning of the Study: Drawing on the four-frame model for organizational change— **people, structures, symbols, and power**, (Reinholz & Apkarian, 2018)**,** we characterized, from expert consensus, the *commitments* and *cultural characteristics* that lever/restrain GS TPD in biology departments. While culture is hard to define, understand, and measure, it is a critical component of deep and sustainable change. We define culture as a historical and evolving set of *structures* and *symbols* and the resulting *power* relationships between *people* (Reinholz & Apkarian, 2018). It is against this backdrop that we believe that studying the set of *structures* and *symbols* and the resulting *power* relationships between *people* would help us better understand the underlying departmental cultural characteristics and commitments that support/restrain GS TPD (Reinholz & Apkarian, 2018).

Significance of the research: The study aims to use the results and findings to build a theory of change, which could serve as a guiding framework for organizing GS TPDs across Biology Departments. Additionally, ranked expert results and findings could help identify easy to—and/or difficult to—change cultural commitments and departmental characteristics for GS TPD in biology departments.

Research Questions: The following research questions have been posed to guide the study:

1. What *cultural commitments* and *departmental characteristics* make some departments more (or less) likely to provide support for graduate student teaching PD?
2. What are the *consensual biology department cultures and characteristics* that graduate student teaching professional development (GS TPD) experts believe are associated with departmental support for or resistance to GS TPD?

Methods & Data Analysis Procedures: To gather collective opinion, through consensus, and understand the *barriers* and *levers* regarding the *cultural* commitments and departmental characteristics that influence GS TPD, we adopted a Delphi design for the study (Busch & Rajwade, 2024; Bourrie et al., 2013; Churchman & Schainblatt, 1965). The Delphi technique allows expert panelists to achieve consensus among experts regarding a specific issue of interest (Okoli & Pawlowski, 2004; Taylor & Meinhardt, 1985). In particular, it allows a deep dive into concepts that show “uncertainty in a domain of imperfect knowledge" (Bourrie et al., 2013, p.6).

We utilized a Delphi design to seek consensus from expert participants (n=45) on what departmental levers are most salient in supporting or limiting GS TPD. From a large pool of experts (n=467) we initially selected our expert sample, through a screening survey. In stage one of the Delphi study, expert participants generated a wide range of ideas on departmental cultural commitments and characteristics through a structured interview protocol.

These ideas were analyzed using *a priori, open coding,* and summarized into a list using *content analysis*. In the second phase of the study, assembled *supports* and *barriers* of the results of structured interviews were provided to the participants for ranking, along the dimensions of “difficulty to change” and “impact on existence of GS TPD”. Finally, adjustments and feedback of rankings and an opportunity to re-rank, based on feedback from other participants, were applied to achieve consensus, using a survey.

Summary of Results & Findings: Data collection is still ongoing. However, initial data analysis from pilot, prescreening expert data, and structured interview, from consensus, show variedly ranked *departmental characteristics and cultural commitments*. From the *people* frame standpoint, results underscore bystander effect, faculty buy-in concerns, and lack of designated personnel to take up (GS TPD) as a core duty, among others, as the main *cultural characteristics and/or departmental commitments* that *barrier* GS TPD in biology academic units/departments.

Further, expert consensus results from *structures* and *symbols* also, respectively, ranked the equation of occasional GS seminars, workshops, presentations, in lieu of full GS TPD; and faculty mentors' skewed interest in research relative to teaching. No major consensual theme has yet emerged from the *power* frame. Regarding the *drivers/levers for GS TPD*, expert results ranked extra work recognition/certification and integration of GS TPD activities into the mission/vision of biology departments.

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POSTER PRESENTATIONS

AUTHORS AND ABSTRACTS

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An Exploration of Thwarted Belongingness and Perceived Burdensomeness Among Undergraduate Agriculture Students

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Introduction

Suicide is the second leading cause of death for persons aged 10-34 years old (Cuthbertson et al., 2022). Generation Z (adults ages 18-22) is the loneliest generation and are increasingly concerned "that others do not like me" (p. 5) (Center for Collegiate Mental Health, 2023). Individuals with occupations in agricultural sectors face higher rates of suicide, depression, and psychological distress; additionally, there are stigmas in certain agricultural communities pertaining norms of stoicism, individualism, and the perception that seeking help is a weakness (Stewart et al., 2015). This study is motivated by the awareness of suicidal ideation in agriculture, with the additional emphasis by [university]. In 2021, a survey was distributed to 1,900 [university] students; 16% of respondents reported thoughts of suicide (DeGennaro, 2024).

This study investigates experiences with thwarted belongingness (TB), defined as having a low sense of acceptance, and perceived burdensomeness (PB), defined as feeling taxing to others (Van Orden et al., 2010; 2012). Using the Interpersonal Needs Questionnaire (Van Orden et al., 2012), we investigated various stressors and associated risk with TB or PB, including students' age, gender identity, academic rank, employment status, living situation, tuition responsibility, and social media use (Feinstein et al., 2022; Heckman et al., 2014; Lockman & Servaty-Seib, 2016). Research questions for this study include: 1. To what extent do undergraduate agriculture students experience TB? 2. To what extent do undergraduate agriculture students experience PB? 3. Are undergraduate agriculture students' feelings of TB associated with PB, or any stressors? 4. Are undergraduate agriculture students' feelings of PB associated with TB, or any stressors?

Theoretical Framework

This study uses the Interpersonal Theory of Suicide (ITS) to position the research (Van Orden et al., 2010). Within ITS are the linear constructs of thwarted belongingness (TB) and perceived burdensomeness (PB) and a third construct related to the capability to conduct self-harm (Van Orden et al., 2010). ITS positions that TB will vary over time, it is a dynamic state that can be influenced by interpersonal environments, i.e. number of social media friends, and intrapersonal factors, i.e. viewing others' actions as signs of rejection (Van Orden et al., 2010). PB is also a dynamic state of cognition that can vary over time and in severity, it has two interpersonal dimensions: feeling a liability to others, and thoughts of self-hate (Van Orden et al., 2010). The Interpersonal Theory of Suicide was used to develop the Interpersonal Needs Questionnaire (INQ) for use by researchers and clinicians as a risk assessment and crisis intervention (Van Orden et al., 2012).

Methodology

This study occurred at a non-land-grant university in the southeastern United States. We collected the university email addresses for 398 enrolled students who met the inclusion criteria at [university] during the 2024 Spring semester. We conducted a random number assignment to the emails, and using a research randomizer, selected a sample of 196 (Krejcie & Morgan, 1970). Recruitment emails went out to students once a week for 3 consecutive weeks (Dillman et al., 2014). We received a 15% response rate, due to incompletion, only 25 responses were used for analysis. Survey questions included the 15-item Interpersonal Needs Questionnaire (INQ) (Van Orden et al., 2012) and nine demographic questions. For the INQ students answer each item on a 7-point Likert scale, nine items are associated with TB, and six items are associated with PB; an example item on the INQ is “These days, I rarely interact with people who care about me” (Van Orden et al., 2012). Research provides evidence of validity and reliability of both subscales and consistent coefficients were found for TB items ($\alpha = .85$) and PB items ($\alpha = .89$) (Van Orden et al., 2012). The demographic questions were related to perceived stressors.

Results

For RQ1, descriptive statistics were conducted using student’s TB scale score (Boone & Boone, 2012). Based on the 9 items, student’s TB scale scores ranged from 53, stronger experiences, to 9, fewer experiences of TB, $M = 24.04$, $SD = 10.28$, For RQ2, descriptive statistics were conducted using student’s PB scale scores (Boone & Boone, 2012). Based on the 6 items, student’s PB scale scores ranged from 33, stronger experiences, to 6, fewer experiences of PB, $M = 10.24$, $SD = 6.3$. For RQ3 a multiple linear regression was conducted to examine the factors associated with PB. The regression model was statistically significant, $F(8,16) = 14.33$, $p < .001$, with an R^2 value of 0.877, the model explained approximately 87.7% of the variance in PB. Other predictors were not statistically significant in this model. For RQ4 a multiple linear regression was conducted to examine the factors associated with TB. The regression model was statistically significant, $F(8,16) = 18.47$, $p < .001$, with an R^2 value of 0.902, the model explained approximately 90.2% of the variance in TB. Other variables were not significant predictors of TB, indicating no substantial impact on TB in this sample. The high adjusted R^2 value (0.853) suggests a robust model fit, supporting the overall predictive power of the included variables.

Conclusions

To answer RQ1, undergraduate agriculture students’ experiences with TB is varied but somewhat high. To answer RQ2, undergraduate agriculture students’ experiences with PB is low. To answer RQ3, TB was positively associated with PB ($\beta = 0.597$, $p < .001$), suggesting that individuals experiencing higher levels of TB tend to feel more burdensome. Employment status was also positively associated with PB ($\beta = 3.83$, $p = .007$), indicating that employed individuals reported higher PB than their non-employed counterparts. The high adjusted R^2 value (0.816) supports a strong model fit, suggesting that TB and employment status are key contributors to feelings of PB. To answer RQ4, PB was positively associated with TB ($\beta = 1.27$, $p < .001$), suggesting that individuals with higher PB tend to experience higher levels of TB. Age was also a significant predictor, with individuals under 24 reporting lower TB scores ($\beta = -7.43$, $p < .013$), indicating that younger participants may experience less TB. Employment status was inversely related to TB, with employed individuals reporting significantly lower levels ($\beta = -4.35$, $p < .044$), potentially reflecting the social benefits of workplace interactions. Additionally, living at home was positively associated with TB ($\beta = 5.01$, $p < .016$), suggesting that individuals residing at home may experience increased feelings of TB.

Implications and Recommendations

The findings of this exploratory study suggest that perceived PB and TB are related; supporting the theory that people struggling with social integration may experience heightened perceptions of being a burden due to their perceived lack of contribution to their communities

(Van Orden et al., 2012). One implication of this study is we did not collect demographic data on students race or ethnicity, and another implication is the small response rate, therefore the results of this study are not representative of the population. As this was an exploratory study, researchers will use these findings to inform larger, multi-university studies with additional layers of comparison with undergraduate agriculture students experiences with thwarted belongingness and perceived burdensomeness.

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Catalyzing Departmental Change: A Literature Review of Barriers, Drivers, and Framing

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Project Significance and Background Literature

There is an increasing need for fundamental change in the teaching of science, technology, engineering, and mathematics (STEM) in the higher education system so as to maintain the United States' role as a leader in science and technology (NSF, 2020). The implementation of innovative teaching strategies–such as active learning–has the potential to increase both persistence and graduation rates within STEM fields, thus supporting the maintenance of a diverse and competent workforce (Henderson et al., 2011). Furthermore, students in STEM courses utilizing innovative teaching strategies obtain a deeper understanding of the material than their peers in traditional lecture-based classrooms, contributing to a knowledgeable STEM pipeline (Corbo et al., 2016; Sachmapazidi et al., 2021). While much research has applauded the use of new and engaging instructional methods, the majority of undergraduates are still taught using traditional lecture-based methods (Stains et al., 2018). A deeper cultural shift may be required for these novel instructional methods to be embraced outside the STEM educational research community.

As academic departments play a pivotal role in influencing teaching quality, one natural entry point for enacting instructional change is to focus on departmental culture (Couch et al., 2024). This prioritizes the underlying teaching culture of the department as the unit of change, rather than focusing on the development and distribution of pedagogical "best practices" (Corbo et al., 2016; Henderson et al., 2011). Examples of such culture-level changes include fostering increased teaching collaboration among faculty members, promoting inclusivity for all students, and advocating for a growth mindset toward teaching strategy (Bleiler-Baxter et al., 2021).

While the implementation of change efforts is an inherently individualized process for each department, value can still be found in identifying key factors that have the potential to impact–whether positively or negatively–the change process. This exploratory literature review aims to identify potential barriers and drivers of departmental teaching culture change as well as obtain strategies for framing change to encourage engagement. Potential implications of these findings with respect to implementation will also be discussed.

Research Questions

This literature review addresses three primary questions related to catalyzing departmental change:

1. How should change be framed in order to encourage individual and departmental engagement?
2. What are possible barriers to initiating departmental change efforts?
3. What are possible drivers for initiating departmental change efforts?

Methodology

An exploratory literature review was conducted to address our research questions. Literature discussing cultural change was initially identified through a keyword search of *(departmental) cultural change*. This selection was then narrowed down via the exclusion of papers that did not directly address issues related to the initial "buy-in" or catalyzation of change. After further examining the abstracts and keywords of the remaining papers, the five most explicitly pertinent papers were then selected for more in-depth analysis. It should be noted that while our primary focus was literature within the context of academia, a sample of literature situated outside this context was also identified so as to enhance the breadth of our exploration. In particular, ideas were drawn from a business-organizational framing (Gagliardi et al., 1986) as well as within the cultural context of immigration (Kunst & Mesoudi, 2023); these provided supplementary perspectives and interpretations across the dimensions of cultural change that were then leveraged for the development of a more global understanding of the mechanisms of change. Findings concerning barriers, drivers, and framing related to catalyzing cultural change were identified during this detailed review and then further synthesized into key themes related to each of our three research questions.

Summary of Findings

Findings are summarized below by research question.

Framing of Change The way in which the idea of change is introduced can greatly impact the reception to implementation of change efforts; as such, consideration should be taken to how change is presented. In particular, change should be characterized as follows: change is at the departmental level (Gagliardi et al., 1986), change is student centered (Quan et al., 2019), everyone is a collaborator/contributor in change efforts (Quan et al., 2019), change will have positive collective and individual outcomes (Kunst & Mesoudi, 2023), and change efforts are grounded in data (Quan et al., 2019).

Barriers to Change By identifying potential barriers that may impede efforts to introduce and implement change, it is possible to avoid or at least mitigate some of these roadblocks. Faculty may be resistant to change due to the following reasons: lack of professional knowledge/skills (Corbo et al., 2016), lack of time and/or resources (Gaubatz & Ensminger, 2017), fear of the unknown (Gaubatz & Ensminger, 2017), satisfaction with the status quo (Gaubatz & Ensminger, 2017), lack of input on change decisions (Gaubatz & Ensminger, 2017), and resistance to external leaders with potentially different values (Gagliardi et al., 1986). Additionally, Gaubatz & Ensminger (2017) identified former chairs or individuals who unsuccessfully applied for the chair position as the most likely to be actively contentious resistors to change efforts.

Drivers for Change By identifying and leveraging potential drivers that may facilitate and encourage change, the process of shifting departmental culture can be eased. Some drivers include: lack of conflict between current departmental values and the values associated with the proposed change (Gagliardi et al., 1986), celebration of positive outcomes at both the individual and collective levels throughout the change process (Couch et al., 2024), reinforcement of change as an ongoing iterative process (Gagliardi et al., 1986), a commitment to diversity and inclusion (Quan et al., 2019), and the leveraging of formal and/or informal departmental leaders as agents of change (Kunst & Mesoudi, 2023).

Implementation Implications

Conducting baseline assessments and building relationships can be a pivotal first phase in transforming departmental teaching culture; these preliminary activities uncover specific barriers and drivers in a department, paving the path for future discussion and allowing greater insight into the innerworkings of the existing culture structurally, socially, and scholastically. Such initial work can also ease reception to proposed changes later in the process. With this context in mind, the findings of this literature review can be leveraged to enumerate the following action items as essential preliminary activities in catalyzing departmental change. First, current departmental values must be identified to ensure they are not in conflict with the proposed change. Conflict in values acts as a barrier to change, so it is necessary to reconcile these conflicting values via the reframing of change within the preexisting departmental value system. Second, the identification of current departmental needs is vital in order to leverage them as positive outcomes of change. In particular, dissatisfaction with current practices and/or infrastructure (i.e., the status quo) can function as a possible driving agent. Finally, departmental leaders should be identified so as to be leveraged as agents of change; this includes both authoritarian leaders such as chairs as well as peer leaders deemed as influential by their peers.

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Chemistry Bridge: An Outreach Program for Incoming High Schoolers

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Colleges and Universities are uniquely equipped to actively engage surrounding communities with a variety of opportunities to learn. More specifically, it is critical for higher education institutions to develop programs that allow for these communities to participate in the sciences. These programs can motivate precollege students to pursue careers in sciences and have a positive outlook on the physical sciences.[1]

Figure 1: ChemBridge Participants launch a water rocket as part of one of the camp activities.

This poster presentation will outline an The Chemistry Bridge Program. It is a day camp designed for rising high schoolers to a hands-on experience in a university chemistry laboratory. The program typically involves a faculty host, a Graduate Teaching Assistant, and two to three Undergraduate Teaching Assistants, and a total of twelve to twenty participants. Over the course of a week, campers have the chance to learn chemistry through a variety of experiments involving The Scientific Method, colors, microplastics, DNA, and redox reactions. In addition to these experiments, research active faculty and graduate students also present research in their laboratories to give the participants a perspective of the day-to-day job of scientists. Ultimately, the goal of this poster is to provide insights on how this program, or portions of it, can be implemented at other institutions and the positive feedback that has been given by both ChemBridge mentors in participants.

1. Godínez Castellanos, J. L. et al *J. Chem. Educ.* **2021**, *98*, 1266-1274

CURE Inception: Teaching Undergraduate Biology Students Science Communication About Culturally Controversial Topics by Having Them Research How Undergraduates Currently Communicate About Culturally Controversial Science Topics

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Project Overview

Undergraduate biology students rarely graduate with training on how to communicate with non-scientists about culturally controversial science topics (CCSTs), which may lead to them using ineffective communication strategies that can result in a mistrust of science. Gaining trust is a primary goal of effective communication and is critical when discussing CCSTs such as evolution, climate change, and vaccines. Undergraduate biology students may be uniquely positioned to communicate about CCSTs because they are more culturally diverse than professional scientists and yet still have a college level education in biology that may afford them credibility within their communities. Yet, science education researchers are just beginning to explore how undergraduate biology students currently approach discussing CCSTs with nonscientists and how to increase key targets that predict students' communication skills. We aim to further this knowledge while promoting student training in both the scientific process and in science communication by developing a Course-based Undergraduate Research Experience (CURE). This course will allow students to (1) perform authentic social science research by exploring communication strategies among undergraduate biology students and (2) gain experience in study design, performing qualitative research, and interpreting quantitative data while concurrently learning the skills needed to communicate science to audiences without formal science backgrounds. To determine if our learning outcomes are met, students will be evaluated on their research skills as well as their knowledge, value, and self-efficacy in communicating about CCSTs. Additionally, our course design will be assessed for its ability to provide students with an authentic and engaging research experience. We anticipate that this CURE will provide us with the baseline data needed to effect changes in how biology students communicate CCSTs. Moreover, the science communication skills the CURE students learn will be essential in combating misinformation and reducing controversy that may be present in their own communities.

Background

Communicating science to general audiences is a desired outcome in undergraduate STEM education[1]. However, there are few opportunities to communicate science with the public, and usually little to no training[2]. This issue is compounded when the discussed science topic is considered controversial (e.g., vaccines). Culturally controversial science topics (CCSTs) are subjects for which there is scientific consensus regarding the topic but a lack of consensus within certain groups (e.g., ethnic, religious, or political)[3]. Research shows that biology students often discuss CCSTs with their peers and community members, yet may feel underprepared or communicate ineffectively[3,4]. Undergraduate biology students belonging to groups that historically distrust science have the potential to reconcile scientific evidence and their community's values[3], so it is essential to adequately prepare students for meaningful conversations within their communities that could promote public health and global stewardship.

CUREs engage students in authentic scientific research by producing novel data that is relevant beyond the classroom while developing essential research skills and collaboration among peers[5]. Successful implementation of CREs is hypothesized to increase students' self-efficacy and belonging within scientific communities[6] and promote retention in STEM majors, which may lead to more students pursuing careers in STEM[7]. By conducting research on students' communication strategies who are at their academic level, we aim to teach CURE students research skills for how to conduct a robust educational research study and also bring their awareness to the potentially effective and ineffective communication strategies that are prevalent among their peers.

Research Goals, Pedagogical Goals, and Methods

Research goals: *Students taking the CURE* will conduct a study exploring the following research questions: RQ1) What types of communication strategies do undergraduate students report they would use when communicating with someone about three different CCSTs: evolution, climate change, and vaccines? RQ2) How do students' communication strategies differ based on the topic as well as their own social identities (religious affiliation, political affiliation, and ethnic identity)? To answer these questions, CURE students will analyze open-ended survey responses from ~1600 undergraduate biology students in which they described how they would communicate about evolution, vaccines, or climate change. The CURE students will analyze the open-ended responses by identifying the common strategies the undergraduate students in our sample reported using. Then the instructors will help CURE students do a quantitative analysis relating the different strategies used to the topics and social identities of students.

Pedagogical Goals: Researchers studying the pedagogical effectiveness of the CRE will ask: RQ1) To what extent do CURE students gain value, self-efficacy, and knowledge in effective science communication about CCSTs? RQ2) To what extent do students report they felt they were conducting broadly relevant and novel research in the CURE? RQ3) Did participating in the CURE increase students' sense of belonging, science identity, or intentions to pursue a STEM career? To answer these questions, we will assess both the course outcomes and student outcomes[8]. To answer RQ1, we will survey CURE students before and after the CURE on their value, self-efficacy, and knowledge of CCST science communication using developed surveys with validity evidence. Previously published survey questions will be used to gauge student perceptions of their belonging[9] and intentions to pursue a STEM career (RQ3)[10] and assess the course for its ability to provide an authentic research experience to students (RQ2)[11]. To understand if students taking our CURE developed appropriate analytical skills, they will be tested on their ability to analyze novel qualitative data and interpret novel quantitative data.

Anticipated Outcomes and Their Significance

The data produced in our CURE will be used to understand current biology students' ability and motivation to communicate CCSTs with people who have opposing views. This data is the starting point from which we aim to develop science communication tools that may be implemented in university classrooms to address inefficiencies in science communication at a large scale. Additionally, CURE students will gain the knowledge needed to communicate science to both scientists and laypeople, a valuable skill for a future STEM career[12]. Students may also gain confidence in talking about CCSTs with others in a culturally sensitive manner, which could help reduce misinformation within their communities. Finally, students will gain experience in social science research. Working with scientists and other biology students may increase their perceived belonging within the science community, which can encourage their retention in STEM majors and lead them to pursue careers in STEM.

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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

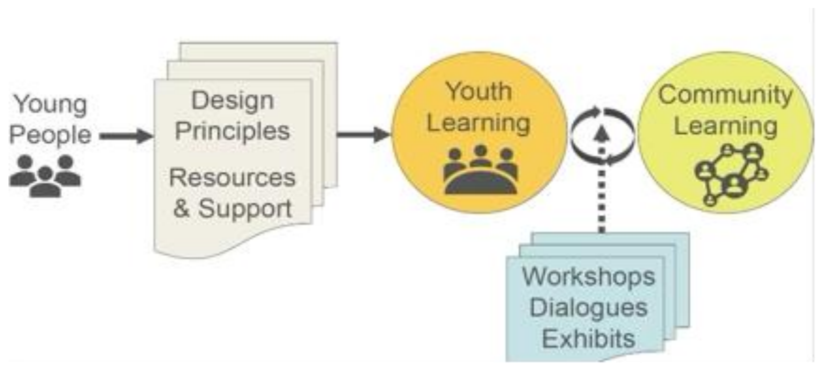

Figure 3. MVP Theory of Action.

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). 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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Developing Instruments to Evaluate and Improve Undergraduate Interpersonal Science Communication About Culturally Controversial Science Topics

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Introduction

Science communication is a critical skill to develop in undergraduate science classrooms (American Association for the Advancement of Science, 2011; Clemmons et al., 2020; Scheufele, 2014). These skills are especially important when communicating about culturally controversial science topics, which are topics for which there is scientific consensus but public debate (Pierre, 2020; Sarathchandra & Haltinner, 2020). Previous work has shown that undergraduate students are already engaged in interpersonal communication about these topics, but they report using ineffective strategies and lacking sufficient training to feel confident in these conversations.

The majority of existing science communication training targets graduate students or science professionals and focuses on public facing communication or communication between scientists (Dudo et al., 2021; Mercer-Mapstone & Kuchel, 2016). This means that undergraduate students are unlikely to receive any training on interpersonal science communication during their degree programs and that those that do not pursue graduate training or professional science careers may never receive any instruction at all. To support greater trust and connection between science and society, we need trainings focused on interpersonal science communication targeted at undergraduate students (Weingart & Guenther, 2016). However, we first need instruments to assess students on this topic in order to establish baselines, evaluate trainings, and identify opportunities and barriers to communication. Using the frameworks of Expectancy Value Theory and the Theory of Planned Behavior, we are developing a set of instruments to evaluate undergraduate students' value, self-efficacy, knowledge, and skill for interpersonal science communication.

Research Questions

To develop and assess the instrument, we have aimed to answer the following questions:

1. How can we evaluate undergraduate biology students' value, self-efficacy, knowledge, and skill for interpersonal science communication about culturally controversial topics?
2. To what extent are the different content areas of each of these constructs (value, self-efficacy, knowledge, and skill) interrelated?

Methodology and Timeline

During the summer of 2024, we engaged in the iterative process of generating items for each of our four instruments. We began with a comprehensive review of the literature to identify existing instruments and their items that may inform our instrument development. We identified 19 existing instruments that measured concepts related to our instruments and evaluated each for their evidence of validity and relevance to our specific context of interpersonal communication about culturally controversial topics. We also drew from the literature on value, self-efficacy, and knowledge to identify the content areas for our instruments. We then generated new items and adapted existing items to reflect our objective and these content areas.

After instrument items were generated and revised, we solicited review from experts in the fields of education research, science communication, and interpersonal communication. These experts evaluated each item on how likely it was to measure the constructs of value, self-efficacy, knowledge, and skill and provided feedback. After another round of revisions and a review by 8 undergraduate and graduate students doing biology education research for clarity and structure, we distributed the survey for pilot data collection. The final survey consisted of likert-scale agreement questions for value and self-efficacy, true/false/I don't know and multiple-choice items for knowledge, and a set of free response questions for skill, as well as a section to collect demographic data.

In the fall of 2024, we distributed our survey instruments to students in undergraduate biology courses (n = 1581) and have thus far received 667 completed surveys (response rate = 42.2%).

Data Analysis and Results

To evaluate the validity of our survey instruments, we used R to conduct Exploratory and Confirmatory Factor Analyses for the value, self-efficacy, and knowledge instruments. We additionally calculated Chronbach's Alpha to determine reliability. We are using these data to further refine and revise the instrument and prepare for cognitive interviews and a second round of expert review.

Conclusion

It is critical to prepare undergraduate biology students to engage in interpersonal communication about culturally controversial science topics to help increase trust in the scientific community and inform key decisions like voting and public policy. This instrument will provide an avenue to evaluate students existing beliefs, knowledge, and skills, provide targeted instruction to improve skills, and to evaluate the efficacy of that instruction.

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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 investigates how a programable robot controlled by a TI-Nspire calculator called a TI-Innovator Rovers can be integrated into Algebra 2 and Pre-Calculus lessons and 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, 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 9 weeks 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-assessments. 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 (Aug 12 - 30): Introduction to TI-Innovator Rovers and foundational programming skills.
- Weeks 4-8 (Sept 2 - Oct 4): Problem-solving tasks focused on mathematical concepts and computational thinking skills.

- Weeks 9 (Oct 7 - 11): Final assessments and data collection.

Data Analysis & Results:

At the time of this submission, the final lessons are being taught in the Algebra 2 and Pre-Calculus classes. Once the 9-week period 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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Evaluating the Effectiveness of an Integrative Education Implementation in Biology Classrooms on Increasing Student Sense of Belonging

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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 will focus 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 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] This study hopes to demonstrate 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.

Methodology

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

Survey: A modified version of the Colorado Learning Attitudes about Science Survey (CLASS)[6] will be 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 will allow 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 will cover the four course modules. These topics will be the same for both groups and will 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 will be validated by interviewing 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 will be analyzed utilizing Braun and Clarke's (2022)[1] thematic analysis. This thematic analysis will be conducted using a deductive (top-down) and inductive (bottom-up) 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. A deductive approach can be used as the starting point which allows analyzing data in relation to the themes that have emerged through the review of literature done for the study or the research questions designed for the study.

Results

The study is currently collecting data to be analyzed at the end of the Fall 2024 semester.

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Exploring the Impact of Project-Based Learning in Theory of Flight Classes: A Case Study on Glider Performance 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.

Faculty Perspectives on Using Learning Assistants (LAs) in Undergraduate Introductory Science Classes

Monsour Zakariyah & Katy Hosbein
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Introduction

In recent decades, numerous calls have been made to adopt more active, student-centered approaches in science courses. These methods have improved student engagement, participation, and performance compared to traditional lecture-based courses (Freeman et al., 2014). One program that has shown promise in supporting instructors as they shift to more student-centered instructional practices is the Learning Assistant (LA) model (Otero et al., 2010). The LA model utilizes undergraduate students to join the course instructional team to facilitate learning in courses with high enrollment and DFW rates. LAs are trained in pedagogical techniques and work with their assigned course instructor to give feedback on content delivery.

One of the main goals of the LA program is to provide instructors with resources that encourage the adoption of more active instructional practices in the classroom. Research has shown evidence of this goal: faculty collaborating with LAs shift from traditional lectures to more active instruction (Hill et al., 2024; Barrasso & Spilios, 2021). However, limited research explores the impact of using LAs for instructors who have already adopted active practices in their courses before being exposed to this resource. This poster aims to investigate the implementation of LAs in two introductory science classes through the lens of faculty and the impact of working with LAs on their professional growth and instructional practices.

Significance of the Research

Although most research is based on LA's effects on student performance, scanty research explores the advantages of LA for faculty growth. Faculty collaborating with LAs often refine their teaching strategies, moving toward evidence-based, active learning approaches (Hernandez et al., 2020; Hill et al., 2024). This poster fills a literature gap by exploring how Discipline-Based Education Research-trained faculty, who have made a prior commitment to adopting student-centered practice, enrich their classroom practice and interaction with LAs in the concomitant process and what can be learned from their efforts (Barrasso & Spilios, 2021). Such an understanding offers a degree of understanding about how LAs support sustainable enhancement of faculty teaching and student learning.

Research Question

This study investigates the implementation of LAs by Discipline-Based Education Research (DBER) faculty to answer the following question:

1. How do instructors with a background in DBER experience working with LAs for the first time?

Methodology

This qualitative study was done with two faculty members trained in DBER who implemented LAs in their undergraduate STEM classrooms for the first time. The faculty was interviewed four times throughout one semester to explore their experiences of LA integration. Analyzing the data by employing phenomenological analysis and inductive coding, we defined themes connected with faculty development, LA collaboration, and classroom dynamics (Borrego et al., 2016). LAs were actively involved in each course by managing group work sessions, overseeing discussions, monitoring discussions, and directing the students' learning. From faculty reflection on weekly meetings with LAs, constant assessment, and modification of instructional procedures were observed.

Findings

Both instructors reported that integrating LAs allowed them to shift from lecture-heavy instruction to more interactive, student-centered methods. Overall, LAs were understood to support group activities and offer opinions on student learning. For instance, one of the instructors let LAs assist in formulating the quiz questions, improving students' responses and LA's pedagogy training. The faculty perceived improved student participation and greater comfort in asking questions, which aligns with previous research showing that LAs help create a supportive learning environment (Clements et al., 2022; Hernandez et al., 2020). Each instructor also reported a perceived improvement in the assessment scores of the students: the students were getting at least 10 points more, which they concluded to be owed to their involvement with LAs. Also, the faculty revealed that LAs improved their ability to teach content consistent with their student-centered principles.

Conclusion

The present work sheds light on how Learning Assistants provided additional support for student-centered practices in teaching and students' engagement in undergraduate STEM courses for two instructors who were already using student-centered practices. Having partnered with the LAs, the faculty trained in DBER put into practice active approaches to teaching practices in a way that boosted learners' performance. They state that LA programs benefit the students and support the faculty's utilization of innovative teaching methods by providing professional development opportunities. Future research should explore the long-term effects of LA integration on faculty development and its broader impact on institutional teaching practices.

Libraries Count: Initial Impacts of a Virtual Learning Program for Library Staff Focused on Early Math with Young children and their Families from Diverse Backgrounds

Alissa Lange (East Tennessee State University),
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Overview

The Early Childhood STEM Lab at East Tennessee State University (ETSU) partnered with the School of Library and Information Studies at the University of Alabama to lead the program, "Libraries Count: Co-Developing a Professional Learning Program to Build Capacity of Library Staff to Support Diverse Young Children and their Families in Math." This poster will report on the process outcomes from our first 2 years of the 3-year Applied Research project, funded by the Institute of Museum and Library Services (2022-2025).

Our project activity goals are the following: (goal 1) co-develop the Libraries Count program with key stakeholders from a culturally-responsive, strengths-based perspective in diverse settings; (goal 2) pilot, evaluate, and iteratively improve the program with collaborators from ten states: TN, AL, AZ, CA, CO, MA, ME, MD, NJ, NY; (goal 3) roll out and evaluate the impacts of the program at scale across all states, and; (goal 4) publish the final Libraries Count program on WebJunction for libraries to access for free nationally. This poster will focus on goals 1 & 2.

Significance

Math skills and knowledge upon entry to kindergarten strongly predict young children's educational trajectories, even into high school [1] The pandemic disproportionately impacted math learning and children from diverse backgrounds [2, 3]. We can draw from the substantial knowledge about how early math develops and how to support early math learning, in addition to the vast assets that diverse children, families, and libraries bring to the table, as we bring in and raise up the brilliance of young children in early math and the adults who support them. However, we must counter the misconception that math is learned in classrooms starting in school because we know that math learning develops all the time, everywhere, starting at birth, especially in the context of families. Barriers to providing sustained support for young children and their families in library settings include adult anxiety related to doing math with children, uncertainty about how to bring early math into library programming, and the limited content typically included in this area in programs to prepare library staff [4,5]. Professional learning (i.e., professional development) could address misconceptions and expand math in libraries, but such programs are rare [6,7,8].

Existing early library-based professional learning programs focus on early literacy (e.g., Supercharged Storytimes hosted by WebJunction), or school readiness broadly (e.g., Reimagining School Readiness), but none focus on math specifically with young children and their families. We have learned that online supports to build capacity with library staff can be effective when they are well-designed (e.g., leveraging expertise of WebJunction) and when they draw from research on principles of effective adult learning [9], and we know the value of a focus on early math for later learning [1]. Critical and central to our work is an emphasis on equity, diversity, inclusion, access, and social justice, including in how our team works and conducts research together; they will be infused meaningfully into the process and product.

Our project will address these challenges by creating and evaluating an online professional learning program, Libraries Count, for library staff to integrate math into programming for diverse young children (ages 3-5) and their families. Ultimately, our goal is to support children and families living in diverse underserved communities who need support the most, like in rural Appalachia and in urban areas (e.g., with large % Latinx population).

Research questions

- RQ 1. To what extent does a collaborative, co-development process between diverse families, library staff, and content experts/researchers empower collaborators (families, library staff, researchers) and result in the creation of an adaptable, sustainable, and culturally responsive professional learning program?
- RQ 2. How do diverse families and library staff view the Libraries Count program in terms of its applicability to their own lives, relevance to their context, and the extent to which it is culturally responsive?
- RQs 3-4 focus on impact and will be reported once the final evaluation year is complete. For the present poster, we will focus on qualitative results and RQs 1-2.

Data analysis procedures

Our data analysis plan includes analysis of mixed methods data sources. Qualitative data will be from a variety of sources, such as formal, informal, ethnographic, and participatory data collection efforts across all years of the project. Examples of qualitative data including meeting minutes from 2-4 leadership team meetings each month and 3-6 Development Group meetings per year, and written feedback from pilot library staff on modules. The qualitative data analysis will be guided by grounded theory [10] and involve deductive coding (e.g., open, selective, axial) as needed to identify categories and themes as well as specific actions to be implemented as a result of recording the phenomena of experiences getting recorded. We will use various strategies to check trustworthiness, reliability, and validity of data findings such as triangulation, member checks, reiterative assertions, and application to next steps. Quantitative data (to be analyzed later) include closed-ended rating items involved in module feedback, Likert ratings of self-reported impacts on library staff, and a factorial vignette design approach to assess impact of the full program on attitudes and beliefs [11].

Summary of Findings

Qualitative analysis focused on our process suggest that the program modules are responsive to the needs of library staff and families from a variety of contexts. In addition, our Leadership Team and Development Group, consisting of library staff, early childhood education researchers, early math researchers, and families, have found that reflection on how we work together including systems and entrenched beliefs about whose voice is valued in research, and how we bring families and their young children from diverse backgrounds into our work in libraries, has strengthened and expanded our own views of inclusivity and what it means to create programs that reflect diverse voices. Implications discussed in relation to social justice designs and approaches to research [12] and how our approach to collaborative co-design might inform other interdisciplinary research efforts.

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Measuring STEM Department Teaching Culture: A Survey Developed Using Self-Determination Theory

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Project Significance and Background Literature

Maintaining competitiveness and innovation in the field of science and technology in the United States requires us to produce a competent, creative, and diverse workforce (NSF, 2020). Yet, many graduates are ill-prepared to contribute to the cutting edge of science due to underdeveloped problem-solving skills and a lack of creativity (NSF, 2020). Moreover, barriers still exist that inhibit the addition of historically marginalized individuals into the STEM workforce (Whipple et al., 2021; Whitcomb & Singh, 2021; Thomas & Larwin, 2023). While research has determined many classroom teaching practices (e.g., active learning) that can promote student retention and diversity (Freeman et al., 2014; Theobald et al., 2020), undergraduates are still predominantly taught through instructor-centered, lecture-based courses (Stains et al., 2018). Therefore, a nationwide teaching reform is needed to recenter our students in the classroom to meet the future scientific and technological demands of our country. To meet these goals, instructors need support in their roles as teachers. For instance, engaging in teaching professional development programs and meeting their psychological needs can motivate them to incorporate more evidence-based teaching practices into their classroom.

The Advancing the Culture of Teaching in STEM through Diffusion of Strength-Based Reflexivity (ACT-STEM) project, an NSF-funded program (NSF #2337168), aims at creating departmental cultures that are collaborative, inclusive, and centered on growth, which can ultimately lead to more inclusive teaching practices to support student retention and success. In the first phase of this project, we will characterize the current teaching cultures across multiple STEM departments within one university. We will use Self-Determination Theory (Deci et al., 2017) to measure individuals' psychological needs of perceived relatedness, competence, and autonomy as it pertains to teaching. Relatedness refers to someone's need to "fit in" and be valued and respected within a group (in this context, instructors and their teaching colleagues). Competence refers to the instructors' need to feel knowledgeable and confident in their ability to use practices that support the learning of all students. Autonomy in this context refers to instructors' need for self-governance to engage in pedagogical advancements. When individuals' psychological needs of relatedness, competence, and autonomy are met instructors can have optimal opportunities to succeed in supporting student learning and success.

When thinking about an instructor's psychological needs, it is also essential to consider the teaching culture the instructor works within. Teaching culture can be defined as "the shared patterns of norms, behaviors, and values of STEM [departments] that manifest themselves in the way courses are taught and the classroom is experienced" (NAS, 2016). Therefore, we will also use Self-Determination Theory as a lens to understand the components of relatedness, competence, and autonomy within the teaching culture of STEM departments. To our knowledge, no instrument exists to characterize STEM department teaching culture using the psychological needs from Self-Determination Theory, thus the aim of this study was to develop this novel survey.

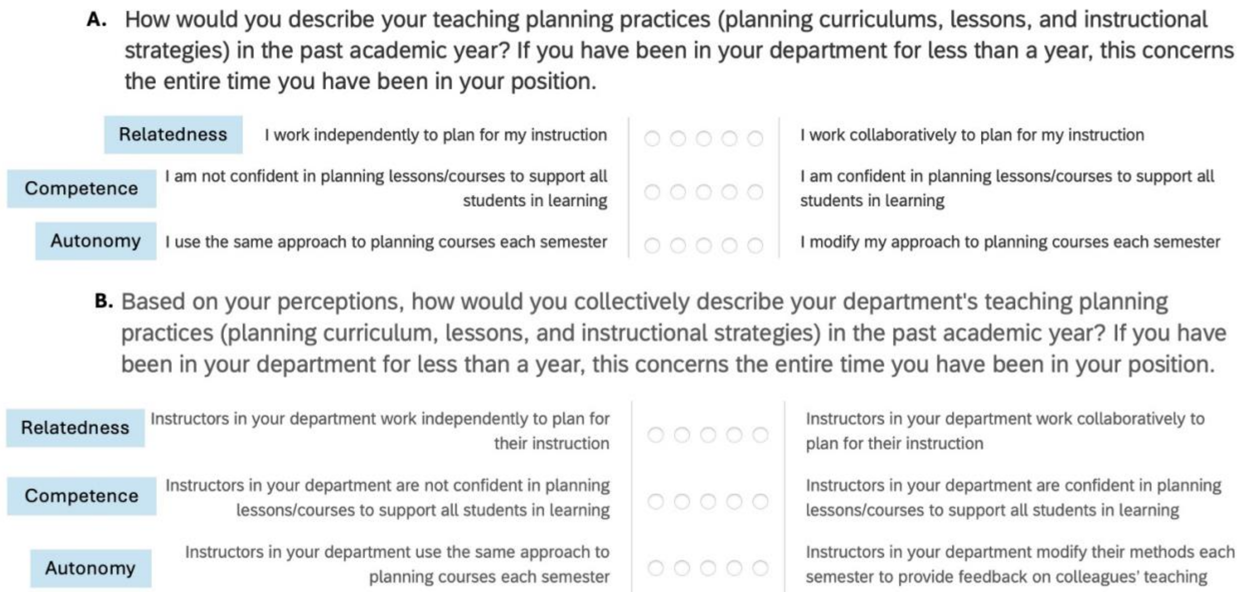
Data Analysis Procedures

To address our project's aim, we first reviewed the Basic Psychological Need Satisfaction at Work Scale commonly used in Self-Determination Theory research for nonacademic work settings (Deci et al., 2001). Because, faculty instructors often hold a variety of work roles related to research, teaching, and service, we initially changed the survey to only reflect their role as educators by substituting "teaching" for "work." We realized, however, that because teaching is multidimensional, we needed to adapt the survey to reflect these different aspects. Our survey measures four distinct dimensions of teaching: 1) planning the curriculum, lessons, and instructional strategies, 2) implementing instructional strategies and managing the learning environment, 3) using formative and summative assessments to measure student progress and provide feedback, and 4) analyzing and reflecting on teaching methods and student outcomes to improve instructional effectiveness and foster growth (Abell et al., 2018). Additionally, we broadened the survey to measure participants' psychological needs at the individual level and to capture their perspectives of the broader teaching culture within their department.

Summary of Findings

The purpose of this project was to develop a survey to characterize STEM department culture using the psychological needs from Self-Determination Theory. Our developed survey has 27 items. Three items collect demographic information about the participant, including which STEM department they are in, their position in the department, and the length of time they have been in the department. Twelve items are focused on the individuals' perceptions of their psychological needs on a continuum for each dimension of teaching. See Figure 1A below for an example focused on the planning dimension of teaching. Similarly, each of these items are rephrased to understand the participants' perspective of the broader teaching culture within their department. See Figure 1B below for a parallel example of an item for the department culture focused on the planning dimension of teaching. This survey can be used to characterize teaching cultures according to Self-Determination Theory to understand how individuals and departments' psychological needs are met for different aspects of teaching. This will also allow researchers to gain insight into the variation among the departmental teaching culture at varying STEM departments.

Figure 1: *Example survey items for the planning dimension of teaching at the A) individual level and B) department level for each psychological need. Blue boxes indicate the psychological need addressed by each item.*



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Partnerships That Live Beyond Graduation Give New Teachers a Feeling of Belonging and the Stamina to Stay

Jill Chambers, Tina Hendrickson, Michael J. Wyss, & Sandra McKell
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Over the last 15 years, the University of Alabama at Birmingham's (UAB) Noyce program has increasingly integrated resources that the preservice teachers can effectively use in-service. One of the most successful parts of the program is its partnership with the Alabama Science in Motion and its parent, Alabama Math Science Technology Initiative (AMSTI), which together provide STEM training and resources to the in-service teachers throughout greater Birmingham, Alabama. Beginning in 2010, the AMSTI and ASIM programs were increasingly integrated with the Noyce by including AMSTI training in the curriculum of the School of Education and the College of Arts and Sciences preservice STEM education training. Monthly, the AMSTI and ASIM specialists engage in collaborative discussions with the preservice/in-service teachers about the resources AMSTI offers to the teachers, and more importantly mentor the teachers on understanding the principles of STEM and how to deal with stress and challenges of the classroom. By increasing teacher confidence and providing a network of support, the teachers learn to belong in STEM teaching, and when challenged with presenting or understanding concepts or their students, they know that the AMSTI specialist will assist, both in-person and virtually.

As a result, teacher attrition rates are decreasing among our Noyce trained teachers. The AMSTI collaboration provides professional development sessions in which teachers deepen their cross-curricular content and develop pedagogical strategies essential to implementing STEM teaching practices and the 3-Dimensional standards of the NGSS. Unlike the typical program, the AMSTI-UAB partnership follows the teachers into the classroom, thus assuring them that they are not alone on a classroom island but have ongoing support and social anchorage in the AMSTI family. This partnership has helped overcome the third-year teacher exit from urban and rural classrooms and helped the teachers realize they are making a difference and can always call for assistance when they feel down or ineffective. The partnership is important to provide new teachers the social-educational support of other professionals, who can assist them in conquering the challenges they face. These partnerships have also resulted in a sustained flow of about 10 new teachers from the UAB program each year, and nearly every UAB Noyce student has graduated and has remained in STEM teaching in high needs schools.

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STEM-STEAM Engagement for Advancing Biomaterials

Karen M. Boykin (University of Alabama at Birmingham), Jonathan R. Bonner, Brian Pillay, Haibin Ning, & Derrick Armstrong (University of Alabama at Birmingham), Coleman Beale & Gabriella Gurau

Summary: The presenters for this poster have been part of research and development (R&D) teams involved in green industrial and technology for processing biomaterials into new businesses and unique jobs. Members of the team created a community education and outreach "Model" for introducing R&D concepts to assisting teachers, students, and community leaders in identify needs around "new products" in unique emerging technology area(s) important for economic and workforce development. Hands on STEM-STEAM bioplastic kits promote student workshops and commercial sales. 525 Solutions outreach was led by the Hale Empowerment and Revitalization Organization (HERO), whose mission is to serve as a catalyst to end rural poverty. Community-based dissemination is assisted by the FAHE Network of local, regional, and national leaders working to support infrastructure and human resources.

Research: The research component of the STEM-STEAM project is part of on-going activities that involve looking at **how to grow workforce opportunities for larger biomaterials projects with communities.** As one example, the hemp biomaterial kit is linked to the industrial hemp industry in the Alabama Blackbelt. The research team from UAB has been working with Bastcore, a hemp processing and research company, to improve production questions as part of confidential competitive grants. **Our core research question has been what methods are most effective for community introduction and engagement**. Historically, surveys, questionnaires, and community canvassing are provided as part of outreach and engagement activities for analysis. Team members involved in prior projects have conducted downtown rural community canvassing for biobased products. The product that is the subject of this poster presentation, a STEM-STEAM leaning kit, focuses on: Sparking Curiosity and Prioritizing Authentic Experiences as well as Community Awareness and Engagement. One kit was assessed with parents providing survey information. The kit is a new product and has not yet been used in a formal learning environment but is planned for middle school where additional surveys will be obtained.

Transformative Learning Principles Experience: The core research conducted by the project team involved introducing the principles of transformative learning whereby students are engaged "where they are", assessing their surroundings, and are given the tools that can help them realize there is "potential" in their surroundings can significantly add to regional creativity as applied to new business creation. These principles are to nurture, guide, and empower students through creative learning, sparking curiosity, and provide authentic experiences that awaken their awareness of their own potential within their surroundings. This was the underlying focus of Dr. George Washington Carver who in an effort to battle the "lowlands of sorrow" began to bring scientific and educational principles that were employed at Tuskegee University into the interrelated fields of science and local farm based entrepreneurial business (Ferrell, J. S. (2007).

It has been suggested that understanding the factors that promote new entrepreneurship (new businesses) is crucial to regional economic development efforts. A high level of new business creation significantly contributes to economic vitality and is a major signal of a dynamic economy. Social diversity and creativity have a positive relationship with new business formation. Lowering barriers of entry into the labor market and diverse culture facilitate the influx of human capital that promotes innovation and accelerates information flow, leading to increased business formation. Thus, new business formation is strongly associated with cultural creativity (Lee, Florida, & Acs, 2004).

Leadership from 525 Solutions, a research and development incubator, recognizes the importance of the George Washington Carver (GWC) new economy model for lending to localized student learning in sustainable materials and entrepreneurial development. Researchers worked with non-profits and Stakeholders Communities to identify platforms for strategic planning and project implementation as part of a U.S. Department of Energy award. Using that work, researchers created an engagement model from which they continue to determine methods for community introduction and concept expansion that consider both scientific and engineering feasibility to include pipelines for education and outreach.

Researchers from the University of Alabama at Birmingham's Materials Processing and Applications Development (MPAD) Center and instructors from the Blackbelt Treasures Cultural Arts Center (BBTCAC) are helping students learn about their community and the impact they can have on the area through developing and exploring local interests. It is anticipated that a positive outcome from this concept can have broad potential for economic growth utilizing training area youth to use local resources.

Guided by 525 Solutions, the stepwise process that evolved from "community of practice" outreach was for the: (1) identification of tools including engaging education outreach and workforce development programs; (2) development of ideas useful in educating the community and public utilizing locally resourced sustainable materials and concepts to benefit the local community; (3) workshop ideas; and promote (4) competitions for utilizing sustainable, renewable, bio-based resources, including bioplastic.

To illustrate the engagement concept, a hands-on learning "kit" using bioplastics was developed by the UAB's MPAD researchers that uses the GWC model and 525 Solutions platform. The first of the bioplastics kit designs incorporates locally sourced agricultural industrial hemp from Bastcore, Inc., a materials processor working with major textile companies in the Alabama Blackbelt. The kit workshop offered by BBTCAC for students includes entrepreneurial skill sets for product development and promotion. BBTCAC workshops are for middle school students held typically at area schools. The kit contains materials for students to mold an artistic bioplastic shape using microwave energy and starch. Molds are fabricated in advance using 3D printed positives to create negative silicon where the bioplastic precursors area introduced and converted to plastic using microwave energy. Teachers and students will be provided a simple survey for assessing (1) interest in the activity, (2) the time to do the activity, and (3) information learned.

Through the exercise of learning about bioplastics, their local and regional sources, and the variety of uses for the material, students begin to understand the importance of nature around them. The exercise begins to provide students with confidence in creating locally made products. The BBTCAC collaboration includes a demonstration on how products combining STEM-STEAM (science and art) can be then locally sold, introducing students to regional business creation. The UAB MPAD collaboration includes research and development understanding into materials processing, using in this case bioplastics, as a career exploration option that can allow students to expand their scientific and engineering knowledge.

Survey data from the parents who tested the kit with their family were provided with a version for children to create a Christmas ornament design. The survey was a simple one-page data collection document that asked respondents to indicate in written form the child's (1) interest in the activity, (2) the time to do the activity, and (3) information learned. Additional questions were: (1) if the child and the family gained knowledge of biomaterials, and (2) would they buy another. The family provided positive information that the child enjoyed the kit, information was learned by both the child and the family, and they would purchase an additional kit.

The art component of the project, created for the Educational Kits that included artwork produced by AGORA graphics, an entity that supports artists who create images for STEM-STEAM kits. After this session, participants will be able to recognize kits are available for students, teachers, workshop presenters, and families for the introduction of bioplastics using STEM-STEAM and entrepreneurial learning principles. Kits include hands-on instruction explaining scientific principles along with reading materials on the George Washington Carver model to help with understanding an individual's place and potential in their local environment. Kits can be purchased from BBTCAC with guidance on how students can begin the process of learning how they can become future STEM-STEAM artists, scientists, and business owners.

The poster presentation outline will follow a workshop introduction for students using the kits. Attendees will be engaged in the kit instruction. After the kit is gone through, including highlights of the science behind bioplastics, the attendee will be provided with how and why the kit was developed. Attendees will spend approximately 3 to 5 minutes going through this information with the presenter, allowing the attendees to ask questions during the presentation process or after. A few kits will be available for teacher and student attendees expressing interest and need may lead to discounts or simply free distribution of one or more kits. Additional kits if desired by attendees can be purchased through BBTCAC at $30 each.

Student Perceptions of Learning Gains in Revised General Education Science Course

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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 and feedback from the students reflected the removal. Response rate was 20%.

More cooperative learning was planned for the fall 2024 semester, based upon the spring 2024 data. IRB has approved this year's data collection. Some labs have been modified to require more collaborative learning. This continuous study will provide data to direct information and strategies used to improve student learning. The major effect seen in restructuring by using multimodal delivery of relevant information is students more interested in science (GAP Technologies, 2022).

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Students Who Prefer In-Person Tests Outperform their Online Peers in Organic Chemistry

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Abstract

To test the hypothesis that students who complete remote online tests experience an 'online grade penalty', we compared performance outcomes of second-year students who elected to complete exams online to those who completed face-to-face, paper-based tests in an organic chemistry course. We pursued the following research questions: (RQ1) Are there performance gaps between students who elect to take online tests and those who take face-to-face tests? (RQ2) Do these two groups differ with respect to other affective or incoming performance attributes? How do these attributes relate to performance overall? (RQ3) How does performance differ between students who reported equal in-class engagement but selected different testing modes? (RQ4) Why do students prefer one testing mode over the other? We found that students who elected to take online tests consistently underperformed relative to those who took face-to-face tests. While we observed no difference between the two student groups with respect to their intrinsic goal orientation and incoming academic preparation, students who preferred face-to-face tests perceived chemistry as more valuable than students who preferred to complete exams online. We observed a positive correlation between performance outcomes and all affective factors. Among students who reported similar levels of in-class engagement, online testers underperformed relative to face-to-face testers. Open-ended responses revealed online testers were avoiding exposure to illness/COVID-19 and preferred the convenience of staying at home; the most common responses from face-to-face testers included the ability to perform and focus better in the classroom, and increased comfort or decreased stress they perceived while taking exams.

Keywords: computer-based exams; paper-based exams; testing mode; testing mode effect; exams; intrinsic goal orientation; engagement; task value; distance education; academic performance

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The Beca Embajadores Global Education Program: Assessment and Implications for Self-Efficacy and Interest in Graduate School

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Introduction

For high school students, being admitted to a university to study science, technology, mathematics, and engineering (STEM) majors is an achievement, but also the starting point of a years-long process fraught with uncertainty. Many intersectionalities interact in complex ways and can result in undergraduates who are STEM-interested or originally declared STEM majors switching to non-STEM majors or dropping out of college (Brewer et al., 2021; Chen, 2015, 2013; Malcom & Feder, 2016; Romash, 2019; Seymour & Hewitt, 1997; Seymour & Hunter, 2019). Latino students from low socioeconomic communities who are the first in their families to access higher education are likely to experience push factors and STEM attrition (Castellanos & Gloria, 2007; Chapa & de La Rosa, 2006; Dueñas & Gloria; Flores, 2011). Successful summer interventions aimed at enhancing graduation rates and improving the self-efficacy of Latino undergraduates have been reported in the literature (Beltran, 2018; Barth et al., 2021; Enriquez et al., 2014).

Research Questions

This study described the main features of the Beca Embajadores Global Education Program (GEP), a summer enrichment program for engineering, technology, and business management students designed by faculty in the Department of Engineering Sciences, Morehead State University (MSU), Kentucky. The research questions were:

- Is there a significant difference in the participants' self-efficacy before and after the GEP?
- Are participants more likely to graduate and apply to graduate school after the GEP?
- What instructional features of the workshops worked the best, as perceived by the participants?
- What did the participants recommend to improve the GEP instructional workshops?

Methodology

The 29 participants were students from the Polytechnic University of Querétaro, the Aeronautic University of Querétaro, and the Technological University of San Juan del Río. The Querétaro State Government selected these students through a competitive scholarship program (Beca Embajadores). At MSU, all students completed workshops on Appalachian and U.S. culture, soft skills for business and economics, science and engineering communication, and engineering economics. Specialized workshops were designed based on the student's career interests, including Robotics and Automation (industrial robotics, drone design), Space Systems (CAD SolidWorks, CanSat Micro-satellite design), and Business Management (quality management, global entrepreneurship, and innovation).

A mixed methods approach was used to collect research data, mediated by a locally designed pre- and post-survey. It included:

- **Self-efficacy scale**. Students were instructed to read a list of workshop topics. On the pre-test, participants were asked to indicate their current confidence level in the topics' knowledge and skills, using a rank scale where "1" represented a low confidence and "10" represents a high confidence in their ability to succeed in these topics. On the post-test, using a similar ranking system, participants were asked to indicate the knowledge and skills they had learned in the workshops.
- **Future academic plans**. Participants were asked how likely they were to recommend the GEP to their college peers back home, finish their undergraduate degree, apply to graduate school in Mexico, and apply to graduate school at Morehead State University before (pre-test) and on the last day of the GEP (post-test). The ranking scale ranged from 1 to 10, where "1" represented a very low likelihood and "10" represented a very high likelihood.
- **Academic workshops**. For each workshop, instructors developed a list of 7-9 instructional objectives. On the pre-test, participants were asked to evaluate their content knowledge and skills in the objectives on a scale from 1 to 10, where "1" represented minimal knowledge or skill and "10" represented proficiency in the knowledge or skills listed.
- **Open response**. On the post-survey, and for each workshop, participants were asked to list one outstanding and valuable part of this workshop, and one thing that they would change to improve future workshops.

Data analysis

For the quantitative data, Mann-Whitney Z statistics were reported for pre- and post-survey pairwise comparisons. This test was selected because of the low sample sizes and the categorical nature of the surveys. Because of the exploratory nature of the study, the minimum level of statistical significance was set at a probability (p) value of 0.05 or less to balance the risks of Types I and II errors. The open responses were manually analyzed using thematic analysis (Braun & Clark, 2012; Creswell and Creswell, 2018; Saldaña, 2021).

Conclusion

On average, participants in the Space Systems workshops improved their content knowledge of CAD SolidWorks (4.9 vs 8.9) and CanSat design (4.2 vs 9.2). Similar improvements were measured among participants in the Robotics and Automation group (5.2 vs. 9.2 in industrial robotics and 5.6 vs. 9.3 in drone design) and the Business Management group (5.8 vs. 8.9 in quality management and 7.0 vs. 9.3 in global entrepreneurship and innovation). Results for the whole-group workshops (7.0 vs. 9.4 for business and economics soft skills, 5.0 vs. 9.4 for science and engineering communication. 3.9 vs. 8.8 for engineering economics, and 4.4 vs. 8.4 for Appalachian and U.S. Culture) were encouraging as well. Most or all the pre- and post-survey scores by objective showed statistically significant improvements.

The qualitative data revealed that participants provided positive feedback on how the instructors designed the content and activities in the workshops, as well as on their interactive and approachable teaching style. A few suggestions included (a) having instructors complete a preassessment on the first day to determine the participants' prior knowledge, allowing the inclusion of enriching or more complex activities or exercises to those with some familiarity with the material to be covered in the workshop, while identifying what students are very unfamiliar with them and provide more individualized instruction; (b) better integrating the theory and the practical activities; and (c) scheduling the workshop to provide additional time for hands-on activities and practice exercises.

Overall, the data demonstrated that an intensive, summer enriching experience can improve the students' perception of their self-efficacy, increase the probability of considering applying to graduate school, and produce significant knowledge gain in engineering and business management topics. Because Latino students from low socioeconomic backgrounds tend to leave STEM majors at considerable rates, government-sponsored summer opportunities like the GEP can help improve STEM retention and, ultimately, lead to a more diverse workforce.

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Grit, Persistence Strategies, and Retention Recommendations from the Viewpoint of USAFA Graduating Cadets in STEM

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Introduction

The commonly used expression "there is no such thing as a free lunch" colloquially illustrates that to achieve an adequate proficiency level in any task, investment in time, effort, and the ability to overcome numerous struggles are unavoidable (Duckworth, 2016; Gladwell, 2008; Toyama, 2024). These and other authors argue that grit is an "effortful persistence" because it combines a consistency of interest factor, that is, a passion to invest effort and zeal in the same goal over time, and a perseverance of effort factor that pushes people to continue working toward the goal (Lechner et al., 2019; Von Culin et al., 2014).

To date, studies on STEM degree attainment at the U.S. Air Force Academy (USAFA) have focused on attrition, shedding light on factors associated with cadets switching from STEM to non-STEM majors, or declaring non-STEM majors even though they were initially STEM-interested in high school or as first-year cadets (González-Espada et al., 2019; O'Keefe et al., 2023, 2022). Although some researchers have explored grit, hardiness, and persistence at other military institutions (Bartone, Kelly, & Matthews, 2013; Buller, 2012; Kelly et al., 2014; Johnston, 2010; Maddi et al., 2017; Whipple & Dimitrova-Grajzl, 2024), there is a lack of research studies in the context of STEM degree completion at military institutions, particularly at USAFA.

Research Questions

This study reports how 37 USAFA graduating STEM seniors overcame five challenges previously identified as responsible for many STEM departures; (a) the fast pace of STEM classes, (b) the difficulty level of quantitative Core (general education) classes, (c) the time-consuming academics, physical education and military workloads, (d) the instructor's teaching ability, and (e) the difficulty for STEM cadets to maintain a competitive GPA and also take advantage of certain benefits and opportunities. The research questions that guided this study were:

- How did cadets overcome five situations that commonly push cadets away from STEM majors?

- What would graduating STEM cadets recommend to the USAFA to support persistence?

Methodology

A random sample of 160 graduating STEM cadets (40 male Caucasian cadets, 40 female Caucasian cadets, 40 male minority cadets, and 40 female minority cadets) received by email an invitation to participate in the study, a brief description, consent information, and a survey link. This solicitation was part of the Spring 2024 DSAT Day, a two-week period where cadets are asked to participate in various academic and non-academic surveys. Of those cadets, 37 agreed to participate in the study; not all cadets completed all survey questions.

A survey methodology was selected because it allowed the researchers to learn from the cadets' unique experiences and narratives, rather than being concerned about generalizability (Check & Schutt, 2012; Creswell, 2012). In the first part of the survey, the researchers provided a list of five main reasons why USAFA cadets switched from STEM to non-STEM, identified from a previous study (O'Keefe et al., 2024) and were asked to describe how they were able to overcome these five challenges and persist in the major. If some of these reasons were not challenging, cadets were asked to explain why. In an open-response question, cadets could elaborate on any other challenges they had to overcome to persist and graduate in STEM. At the end of the survey, cadets were asked to provide USAFA with some recommendations for helping future cadets persist in STEM majors, just like they did.

Data analysis

The open responses were analyzed and coded manually using the phases of Thematic Analysis: (a) familiarization with the data, completed through repeated readings and actively searching for meaning and patterns among emerging noticeable traits on words and phrases collected; (b) initial code generation, to begin identifying core recommendations; (c) sorting and collating relevant data and searching for themes, and (d) review of themes, where the major themes were clarified and named for a user-friendly interpretation (Braun & Clarke, 2021; Saldaña, 2021; Nowell et al., 2017).

Summary of findings

Although there were some differences for each of the five challenges, common themes emerged from the data. The most prevalent one was prioritizing and managing their time efficiently, followed by seeking academic assistance from their course instructors, other instructors from the same academic department, peers, and the Quantitative Resource Center, where tutoring and related academic support is provided. Other emerging themes included self-motivation, learning new study skills and approaches, and switching to a STEM major that better suited the cadet's interests and abilities.

Several responses indicated that the five challenges were not an issue for them, and a few stated that they used AP and Honors classes to validate some of the Core classes that freshmen tend to struggle with. Despite the participants demonstrating grit and reaching their graduating semester, several seemed dissatisfied due to their perception that cadets in nonSTEM majors appeared to have an easier time with their academics, resulting in higher GPAs. This is important because there are certain USAFA benefits and opportunities accessible only to cadets with high GPAs, such as clubs, airmanship, and leadership participation.

Recommendations for helping future USAFA cadets develop their grit and persist in STEM majors until graduation included, (a) fostering intrinsic motivation by including metacognition and motivation topics in Core behavioral science classes, (b) explicitly teaching time management strategies (rather than assuming that cadets will develop them over time), (c) destigmatizing both major switching and seeking tutoring and other academic and non-academic support services, and (d) recruiting and retaining the best instructors in Core classes, while providing adequate professional development in teaching strategies. Cadets described additional suggestions, like making Core classes more practical and applicable to Air Force needs, advising freshmen about the challenges and rewards of pursuing STEM majors, and revising admission requirements to help more cadets validate high school AP, CLEP, and Honors classes, which will reduce their workload and get them started with classes in their STEM major.

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The Disconnect Between Undergraduate Standard Mathematics and Modern Applied Mathematics: A Literature Review

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Project Significance and Background Literature

As technology increasingly becomes a focus in modern society, there is a growing demand for engineers around the world. However, there have been concerns about the amount of engineering graduates from universities, in part due to the high drop-out rates of engineering programs (Faulkner et al., 2019; Flegg et al., 2012). Various studies have attributed this to undergraduate engineering students' struggles with mathematics in their engineering coursework, particularly the transfer of mathematical skills and knowledge from the standard mathematics curriculum (Calculus I-III, Linear Algebra, Differential Equations) to engineering contexts (Ekici et al., 2020; Faulkner et al., 2019; Harris et al., 2015). This calls into question the effectiveness of the standard mathematics curriculum for undergraduate engineering students.

This concern is further highlighted by applied mathematicians at the forefront of engineering and technology research. Chui and Jiang (2013) described a recent shift in applied mathematics from modeling through differential equations to information processing and data science, requiring a different set of essential mathematical concepts and techniques that have not been emphasized in the past, such as Fourier and wavelet analysis. Echoing this idea is prominent mathematician Gilbert Strang, who asserted that "[linear] algebra has become as basic and as applicable as calculus" in engineering and science, as it provides the theoretical foundations to modern mathematical techniques such as Fourier analysis, complex analysis, numerical analysis, and optimization (1988). For instance, the notion that sinusoids are eigenfunctions of linear time-invariant systems is the foundational principle of signal processing and motivates the need to decompose everyday signals into sinusoids using Fourier analysis.

The goal of this exploratory literature review is to study the disconnect between the standard mathematics curriculum and modern engineering mathematics. Due to the breadth of research in the topic, this review will focus on integral transforms such as the Laplace and Fourier Transforms, as this topic provides a bridge between the standard mathematics curriculum (differential equations) and modern applied mathematics (Fourier analysis).

Research Questions

This review will primarily attempt to answer the following two questions:

1. How are the Laplace and Fourier Transforms viewed and taught differently between mathematicians and engineers?
2. Is the current standard mathematics curriculum effective in preparing engineers for their future studies, particularly in the field of Fourier analysis?

Methodology

A literature search was performed using the keywords *Undergraduate Engineering Mathematics Education* and *Undergraduate Applied Mathematics Education* to identify literature discussing undergraduate mathematics education in the context of engineering. Articles that do not address differential equations, Laplace Transforms, or Fourier analysis in undergraduate engineering contexts were excluded. A total of 19 articles were found in the mathematics education context primarily in the International Journal of Mathematics Education for Science and Education and the International Journal for Research in Undergraduate Mathematics Education. A total of 17 articles were found in the engineering education context primarily in IEEE Transactions of Education. Open coding was then performed on the 36 articles in which key words and ideas along with specific excerpts on these ideas were extracted. Themes and connections within the literature relating to the research questions were then identified.

Summary of Preliminary Findings

Preliminary findings with respect to the two research questions are summarized below:

How are the Laplace and Fourier Transforms viewed and taught differently between mathematicians and engineers? A variety of studies analyzed course content and textbooks to reveal how Laplace and Fourier transforms are taught (Abou-Hayt & Dahl, 2024; Hochmuth & Peters, 2021; Peters & Hochmuth, 2022; Rezvanifard & Radmehr, 2024; Rønning, 2021). It was found that Laplace and Fourier Transforms are being taught differently in mathematics and engineering due to the motivation of these concepts. For instance, Rønning (2021) showed that the different questions mathematicians and engineers ask using Fourier Series results in mathematics courses having a strong emphasis on analytical ideas such as convergence properties, while engineering courses having a strong emphasis on linear algebraic ideas such as Fourier coefficients and spectral analysis while teaching Fourier Series. Similarly, Rezvanifard and Radmehr (2024) showed that mathematicians view the Laplace Transform as a tool to solve linear differential equations, while engineers view the Laplace Transform as the key to characterizing and analyzing properties of linear systems without finding closed-form solutions. This results in difficulties for engineering students to perceive the importance of the Laplace Transform (Faulkner et al., 2019; Pennell et al., 2009; Rezvanifard & Radmehr, 2024).

Is the current standard mathematics curriculum effective in preparing engineers for their future studies, particularly in the field of Fourier analysis? Multiple researchers have examined the coherence and transfer of concepts between standard mathematics courses and engineering courses (Czocher et al., 2013; Czocher, 2017; Ekici et al., 2020; Raychaudhuri, 2008). These studies reveal a wide range of discontinuities between the standard mathematics sequence and applied mathematics that may impede student learning. These include the absence of complex numbers in calculus (Czocher et al., 2013), the different roles of continuity and existence and uniqueness theorems between courses and disciplines (Czocher, 2017), and the failure to interpret Fourier series using vector spaces (Ekici et al., 2020). The most prominent discontinuity involves the interpretation of functions. In calculus, functions are viewed as actions (Czocher et al., 2013). In differential equations and applied mathematics, it is foundational that a function is viewed as an object that could be an input to a linear system or something one can take the Fourier Transform of. Czocher et al. (2013) showed that this critical gap is not bridged substantially, implying significant changes need to be made to effectively prepare engineers for their future studies.

Implications

To mitigate the issues discussed in the previous section, mathematics education researchers are leveraging mathematical modeling as an approach to differential equations courses to make the standard mathematics curriculum cohesive with applied mathematics (Czocher, 2017; Kwon et al., 2005; Merck et al., 2021). However, mathematical modeling does not bridge all the incoherencies found in the literature review, such as the use of Laplace Transforms to analyze linear systems, the lack of complex numbers in calculus, and the linear algebraic approaches and interpretations of Fourier analysis such as spectral analysis. These ideas primarily involve the information processing dimension of mathematics, which is critical for modern applied mathematicians and engineers (Chui & Jiang, 2013). Given the density of content in the standard mathematics curriculum, it is difficult to introduce information processing concepts within existing courses without significant cognitive overload. It may therefore be necessary to introduce a separate information processing course, to be taken concurrently with the standard mathematics curriculum and prior to upper-division coursework, for undergraduate engineering students.

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Towards Leveraging AI to Provide Automatic Code Review in a Software Engineering Course

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Introduction

The rise of artificial intelligence (AI) systems with the ability to execute complex tasks has increased over time, with certain computational systems attaining proficiency on par with human experts and professionals (Vaswani et al., 2023). Since its inception in 1950, there have been discussions regarding the potential of incorporating AI into the educational framework to enhance student learning and increase educational outcomes (Chen et al., 2020). Subsequently, AI has progressively been integrated with teaching methodologies (Zhai et al., 2021).

Nowadays, software developers have begun employing AI and chatbots in various applications for tasks such as code generation, debugging, and pull requests (Chen et al., 2024). A pull request (PR) is a mechanism by which a developer proposes changes containing new features, bug fixes, or improvements from one branch to be merged into another. Collaborators can review and discuss the proposed changes in a pull request before it is integrated into the main codebase (GitHub, 2023).

Recent work has started exploring the use of AI and chatbots in software engineering education as a code assistant (Kazemitabaar et al., 2024), and to produce automated feedback for students' code submissions (Crandall et al., 2023). Furthermore, companies are already using promising AI tools for software development, software such as CodiumAI's pr-agent (CodiumAI, 2024), an AI agent designed to assist developers in reviewing pull requests (PRs) more efficiently.

This paper presents the design of a study exploring the use of the pr-agent in a software engineering (SE) class, with the objective of assessing its impact on students' learning and development as future software developers. The study involves integrating the pr-agent tool into the course curriculum, allowing students to utilize the tool for reviewing their PRs and obtaining automated feedback about their code. The proposed evaluation strategy includes gathering quantitative and qualitative feedback from students to measure the tool's effectiveness in improving their coding skills, understanding of PR processes, and overall learning experience.

Research questions

This research aims to answer the following research questions:

1. Is CodiumAI's pr-agent a beneficial educational tool when employed in a software engineering course?
2. Is the feedback provided by the AI pr-agent useful for students to improve their code?

Methodology

We present a pre/post outcome study to assess the effectiveness of the pr-agent tool in improving students' code, their understanding of pull requests (PR), and the code review process in a software engineering course. In this study, a cohort of students enrolled in a software engineering course will be tasked with implementing changes to the code base of a software system they are working on in groups. Upon implementing the changes, the students will receive automatic feedback from an AI pr-agent tool and need to update their code based on that feedback before they can integrate their changes into the system. The study will compare the student's performance and perceptions before and after integrating the pr-agent tool into the course curriculum. We will compare changes in their skills, knowledge, and confidence through data collected before and after the intervention is implemented; the aim is to assess the impact of the pr-agent tool on the learning experience in the SE class. The study will be divided into three phases: pre-implementation, implementation, and post-implementation.

Pre-implementation

Before introducing the pr-agent tool, the pre-implementation phase will establish a baseline by assessing the students' initial coding skills and their experiences with AI tools. This will be done through a pre-implementation survey and initial assessment. We will also set up student repositories and integrate them with the pr-agent tool during this phase.

Implementation Phase

During the implementation phase, our focus will be on introducing students to the pr-agent tool and monitoring its usage throughout the course. This will involve providing students with a comprehensive introduction to the pr-agent tool through lectures and an activity. The lectures will cover concepts related to software development, versioning control systems, pull requests, and code review. The activity will demonstrate the use of the pr-agent tool. The students will be instructed to use the pr-agent tool for their PRs and code reviews in their group projects. This will enable us to track the number of PRs reviewed, the types of feedback requested and received, the frequency of use, and how students incorporate the feedback into their code.

Post-Implementation Phase

The post-implementation phase aims to evaluate the changes in students' skills and perceptions after using the pr-agent tool and gather detailed feedback on their experiences. We will use a follow-up survey, a final assessment, and focus group discussions to measure students' perceptions of the AI tool, their coding performance, and changes in their skills, knowledge, and confidence. These will provide us with qualitative and quantitative data to answer our research questions.

Conclusion

In education, there is a growing curiosity about the potential impact of technology on student learning. Therefore, it is crucial to explore the ways in which we can employ new technologies, such as AI, to improve students' educational experience. Through this study, we hope to incorporate new technology into software engineering education and provide experiences that closely resemble those that students will have in their careers as software developers. With this study, we strive to gain deeper insights into how we can use AI to teach software engineering and the benefits and challenges of using AI tools to enhance and support the student's learning experience.

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Undergraduate Engineering Project in Embedded Systems Course Guided by External Collaboration and Needs

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Abstract:

An undergraduate capstone project is a critical part of an engineering students' education when the project is designed to engage the student team with challenges of design-to-specifications and build for a real-world problem typically originating within the engineering curriculum. We report an innovative project and the challenges it posed for one student team in the UAB course (EE437/537) Introduction to Embedded Systems. Features of this project may provide an additional path that pushes the boundaries of traditional capstone projects beyond the confines of the engineering program.

One of us (Brande) is a paleontologist interested in the history of a small bivalve mollusk during its life, death, and environmental preservation (Fig.1). A collection of tens of fossils that are each truncated by an erosional plane begs the question as to how and when the erosional surface occurred. A quantitative study of this population requires the measurement and characterization of the geometric orientation of the planar surface relative to the biological axis of each individual mollusk shell. The final product of this project is an output file of three angles that specify a planar surface for each fossil mollusk.

A general set of specifications by Brande was discussed with the student team of (co-authors) Kinney and Trudeau. These included questions of mechanically orienting each fossil on a platform, rotating the fossil relative to a biological axis, sensing and recording the angular orientation, storing and exporting the file of data for Brande's statistical analysis. A cellphone app that Brande could use to control the measurement and storage processes is necessary for operational control.

Translating these general specifications into specific components of an embedded system that generates the necessary data for subsequent analysis and building a working prototype was an experience most satisfying for the student team.

Solicitation of faculty for creative ideas and needs in fields outside of the engineering school may be a rich source of added-value projects that is not often designed into a capstone experience.