Overview of Research Activity

As a researcher, my interests revolve around utilizing technology to improve undergraduate education. Before starting at ERAU, I began using programming langauges to build automated student-to-expert interactions that are critical to improving student learning. I have since expanded my computer skills to include machine learning through a 5-course Coursera specialization. I am now uniquely positioned as a multi-disciplinary expert in mathematics, mathematics education, and data science.

At the macro learning-level, I can study how different types of educational activities (e.g., discussions, quizzes, exploratory activities, digital manipulatives) may affect student understanding. At the micro learning-level, I can create models that predict how students may respond to individual questions that are used to provide automated feedback. My wide range of educational research, statistics, and programming skills have also led to productive collaborations where I act as an expert in data collection and qualitative/quantitative data analysis to improve undergraduate learning. My active research projects reflect these varied skills that all revolve around improving online education for college students.

My scholarly products, compared to total expectations outlined in the COAS ERAU-W Academic Guidelines and Criteria for Tenure and Promotion to Associate Professor, are provided in a summary chart below.

	Peer-Reviewed Publications	Conference Presentations	Internal/External Funding Proposals
Year 1	3	5	1
Year 2	3	1	1
Year 3	2	2	3
Year 4	NA	NA	NA
Year 5	NA	NA	NA
Expected	5	5	1
Actual	8	8	5

Peer-reviewed publications were submitted to a variety of well-respected locations: national conference proceedings (4), peer-reviewed mathematics education journals (3), and as a book chapter (1). Presentations primiarly took place at national and regional conferences (8), though I also presented at ERAU-hosted local and regional events (3) and was invited to talk about my research at another university as part of a seminar series (1). All funding proposals I was a part of were successful: I was PI on internal funding (2), PI on external funding (1), co-PI on an NSF grant (1), and will have an additional funding proposal submitted by the end of year 3. Note that while my Record of Activities lists 6 grants, I was brought in as a co-PI on grant [4] after it was submitted and am not counting it in the funding proposal list.

Given the numerous successful funding proposals I have been a part of, I have organized my various research projects below by their funding source and summarized how they fit within my research agenda.

Externally-Funded Research Projects

- **PI**: *Machine Learning Affordances in Collegiate Mathematics Education Research*
    - **What:** This solo project focuses on the ways Machine Learning can enhance the teaching and research of college-level math. Methods to enhance teaching include developing: models for levels of understanding certain mathematical concepts, automatic targeted feedback, asynchronous discovery-based learning activity, mastery-based large-scale mastery-based grading. Methods to enhance research include: data management, machine classification of qualitative coding, and machine classification of question responses.
    - **My Role(s):** All aspects.
    - **How this fits my research agenda** Machine learning provides opportunities to scale up traditional qualitative and quantitative research to improve research results. Moreover, it provides opportunities for asynchronous student-expert engagement that is critical to improving student

learning. The skills and experiences I build in this project are used throughout my various other research collaborations.

- **Co-PI**: *Community of Inquiry and Cognitive Load*
  - **What:** This NSF-funded project focuses on exploring the social and cognitive ways students engage in discussion posts in math and physics courses. It also explores the aspects of cognitive load students perceive as inhibiting their contribution to discussions. Seventeen terms of discussions in two courses, MATH 111 and PHYS 102, were collected for analysis using the Community of Inquiry model.
  - **My Role(s):** Data Management, Data Analysis.
  - **How this fits my research agenda:** A goal of the project is to improve student-student and student-instructor interactions in online discussions to enhance online education. Moreover, the project has collected a massive amount of data – approximately 900,000 sentences of discussion. I leverage the machine learning skills I have developed from my solo project to manage and analyze this data effectively. This provides me an avenue to practice my machine learning skills at scale and illustrate one aspect in which machine learning can enhance collegiate mathematics education research.
- **Co-PI**: *Undergraduate Research for Fully Online STEM Students: Impact of Expanded Curricular Options on STEM Attitudes, Identity, & Career Ambitions*
  - **What:** This NSF-funded project is a continuation of a previous NSF project that focuses on developing resources for supporting undergraduate research in online programs. This second stage will expand the impact to all ERAU-W students, develop an Undergraduate Research minor, expand on resources to support undergraduate research, and study the effects of these efforts.
  - **My Role(s):** Methodology, Data Management, Data Analysis, Outreach.
  - **How this fits my research agenda:** A goal of the project is to improve undergraduates' learning experiences by supporting online undergraduate research. I will utilize my background in educational statistics to evaluate the project's efforts.

Internally-Funded Research Projects

- **PI/Co-PI**: *Collective Knowledge Progression and Proliferation in Asynchronous Calculus Discussion Boards*
  - **What:** This project focuses on developing a theoretical framework for categorizing and analyzing how students develop and share knowledge in asynchronous online discussions. After initial development, we have tested and refined the theoretical framework with pilot data and recently collected preliminary data.
  - **My Role(s):** I work in equal amounts with the other PI, Dr. Zack Reed, on all aspects of the project.
  - **How this fits my research agenda:** Asynchronous online discussions provide the majority of student-student and student-instructor interactions in online courses. Thus, discussions are an important vehicle for enhancing student knowledge. This project is formalizing methods for leveraging machine learning to visually understand how knowledge proliferates over the course of a discussion so that these aspects may be targeted and enhanced by an instructor.
- **PI**: *Undergraduate Covariational Reasoning in Calculus*
  - **What:** This project was the result of mentoring an undergraduate student, Teegan Bailey, for three years. After a year of informal discussion on collegiate mathematics education theoretical frameworks and prominent topics, he chose to investigate calculus students' reasoning on how two different quantities change with respect to one another. Teegan created an applet that showed a bird flying in a helix pattern around a tower in 3d and completed a study investigating a student's thinking while answering questions about the bird's flight.
  - **My Role(s):** Research mentor.
  - **How this fits my research agenda:** Encouraging undergraduate research is an important avenue for enhancing student learning. The student created a program as part of his study that has stand-alone value as an educational tool and fits my agenda of enhancing student learning through technology.

Scholarly Products not Associated to an Active Research Project

- ***Project NExT Activities*** Project NExT (New Experiences in Teaching) is a one-year professional development program designed for early-career faculty to learn about best practices in teaching and research. As part of this program, I organized three special sessions that brought in tenured faculty to speak to research in particular.

- ***Presentations as an Expert in the Field*** As an expert in mixed-methods data analysis, collegiate mathematics education, and technology in education, I have spoke locally at ERAU, at a regional conference hosted by ERAU, and at national mathematics conferences. While this talks may mention parts of other research projects, they primarily focus on speaking to a non-research audience to impart generalized wisdom based on one of my expertise.