Externally-Funded Research Projects

PI: *Machine Learning Affordances in Collegiate Mathematics Education Research*

Research Team:

None

Funding Sources:

- Internally through ERAU-W SEED grant, 10/1/21–6/31/22.
- Internal funding for professional development (Certificate in Data Science).
- External funding for professional development (5-day Workshop).
- Externally through subgrant awarded from NSF grant, 10/1/23–6/31/24.
- Applying for NSF CAREER grant in July 2024.

Roles:

All aspects of the project.

Brief Description by Academic Year:

AY 21-22: Initially, this project focused on developing automated feedback for traditional assignments such as homework, quizzes, and exams. After collecting data funded by the ERAU-W SEED grant [**1**], I discovered that ERAU-W students performed well on traditional assignments but exhibited elementary conceptions of key mathematical concepts such as function, variable, and vector. This lead to a re-design of the MATH 111 course to incorporate discussions that engaged students in developing more sophisticated conceptions of key mathematical concepts. In the interim, I resubmitted a journal article [**3**] on a previous course redesign utilizing automated feedback that covers similar content to ERAU-W's MATH 111 course. The article was eventually accepted and published in AY 22-23.

AY 22-23: While designing a study to explore the impacts of the MATH 111 discussion redesign, I explored ways to leverage technology to improve students' mathematical conceptions through non-traditional assignments. This led to engaging in two major professional development actitives: (1) taking 5 Coursera courses to earn a certificate in Data Science and (2) attending a 5-day workshop on authoring dynamic mathematical activities through a webpage. The certificate in Data Science prepared me to incorporate Machine Learning in both my work on designing automated feedback as well as enhancing my research data management and analysis skills. The 5-day workshop on authoring dynamic mathematical activities allowed me to develop dynamic, non-traditional assignments that would incorporate the automated feedback I had previously established. Moreover, the additional training these professional development activities provided allowed me to be a leader in technology in mathematics education and cohost a workshop [**2**] on technology at a national mathematics education research conference (RUMEC). I was also asked to speak at a mathematics department [**4**] on incorporating technology into mathematics education research due to cohosting the tech workshop at the high-profile conference.

AY 23-24: To formally develop and study one of the dynamic, non-traditional assignments that I began creating as part of the workshop, I have received a small grant [**5**] from the NSF-funded project that hosted the 5-day workshop I attended. In addition, I'm using the skills I learned as part of the certificate in Data Science to integrate Machine Learning into another project and am leading a paper and presentation [**6**] to present this new avenue of research in collegiate mathematics education. These efforts will help me prepare for the NSF Faculty Early Career Development Program (CAREER) grant [**7**] on integrating machine learning into Collegiate Mathematics Education Research due in July 2024. The NSF CAREER grant is a highly prestigious grant that "Supports early-career faculty who have the potential to serve as academic role models in research and education and to lead advances in the mission of their department or organization" (NSF Funding Opportunity). I've already spoken with NSF Program Officers about the project in general and received advice to present the strongest submission possible.

Scholarly Products

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- **[7 - External Grant]** (Submission July 2024) Principal Investigator, NSF CAREER Grant: Machine Learning Affordances in Collegiate Mathematics Education Research, 2024-2029. Award amount: $500,000.
- **[6 - National Conference Proceeding]** Chamberlain Jr., D., Faulconer, E., Wood, B. (pending acceptance, Feb 2024). Using Trees to See a Forest: Leveraging Machine Learning to Classify Student Thinking. Proceedings of the 26th Annual Conference on Research in Undergraduate Mathematics Education: SIGMAA on RUME, Omaha, NE.
- **[5 - External Grant]** Principal Investigator, Doenet (NSF DUE-1915294, DUE-1915363, DUE-1915438) Mini-Grant: Asycnchronous Discovery Activity - Learning to Fly with the Wind. 2023-2024. Award amount: $500.
- **[4 - Invited Talk]** Chamberlain Jr., D. (2023, Mar 29). Predicting Students' Thoughts to Provide Elaborative Feedback. Invited by California State University Bakersfield Mathematics Department Seminar Series.
- **[3 - Journal Article]** Chamberlain Jr., D. (2023). How one instructor can teach a large-scale, mastery-based College Algebra course online. Problems, Resources, and Issues in Mathematics Undergraduate Studies. DOI: https://doi.org/10.1080/10511970.2023.2190183.
- **[2 - Conference Workshop Organization]** Chamberlain Jr., D., Reed, Z., & Keene, K. (2023, Feb 23). Workshop: Research on Technology in Undergraduate Mathematics Education. 25th Annual Conference on Research in Undergraduate Mathematics Education: SIGMAA on RUME, Omaha, NE.
- **[1 - Internal Grant]** Principal Investigator, ERAU-W Faculty Seed Grant: Developing Autonomous, Targeted Feedback in Precalculus, 2021-2022. Award amount: $4,069.

Co-PI: *Community of Inquiry and Cognitive Load*

Research Team:

Emily Faulconer (PI) and Beverly Wood (Co-PI)

Funding Source:

Externally funded through NSF, 6/15/21–5/31/24

Roles:

Student Worker Management, Data Management, Data Analysis, Manuscript Writing, Presentations

Brief Description by Year:

AY 21-22: I was recruited to join this NSF grant **[1]** shortly after starting at ERAU-W to provide data management and analysis expertise. In particular, I was tasked with partially automating the manual data collection process. Before my inclusion in the project, student discussion posts were copied, pasted into a Word document, manually separated by sentence, and manually deidentified. This data management process was prohibitively time-consuming. I wrote several Python scripts to: 1. Scrape PDF files for student and instructor posts. 2. Split all post by sentence and tag the speaker. 3. Deidentify all student and instructor names. 4. Tag all sentences by term, year, course, and section. I shared these scripts and tips on managing large collections of data locally at a Lunch & Learn series **[3]**.

As I led the data management, I also led the group of 6 student researchers we had qualitatively coding these sentences. I also developed Excel sheets to analyze data in a flexible and generic way. We presented preliminary results at a national education conference **[2]** and turned the presentation into an accepted journal publication **[4]**.

AY 22-23: After numerous attempts to improve the accuracy of pulling discussions from PDFs, I refined our data collection and management process by obtaining the discussion post data via Canvas API. Moreover, I wrote Python scripts to perform analysis on the ever-increasing data we collected. At submission of this packet, we have about 900,000 sentences from student discussions from 17 terms of MATH 111 and PHYS 102 (note: Excel regularly crashes when working with 100,000+ rows and thus data necessarily needed to be

restructured for large-scale analysis). I continued to oversee the 6 student researchers as they qualtitatively analyzed approximately 200,000 sentences from discussions.

AY 23-24: Student coders have finished enough data analysis that we can prepare manuscripts. I am leading efforts on a presentation and paper **[5]** on the use of technology for data management as well as automating the coding process using our extensive database of sentences coded to train a machine learning model. These efforts will lead to at least two more publications (one on results of the analysis and another on the machine learning model) by the end of the academic year.

Scholarly Products:

- [**5 - National Conference Proceeding**] Chamberlain Jr., D., McGuinness, P., Faulconer, E., & Wood, B. (pending acceptance, Feb 2024). Using Trees to See a Forest: Leveraging Machine Learning to Classify Student Thinking. Proceedings of the 26th Annual Conference on Research in Undergraduate Mathematics Education: SIGMAA on RUME, Omaha, NE.
- [**4 - Journal Article**] Faulconer, E., Chamberlain Jr., D., & Wood, B. (2022). A Case Study of Community of Inquiry Presences and Cognitive Load in Asynchronous Online STEM Courses. Online Learning Journal. DOI: http://dx.doi.org/10.24059/olj.v26i3.3386.
- [**3 - Local Presentation**] Chamberlain Jr., D. & Faulconer, E. (2022, Apr 21). How We Manage Large-Scale Data Collection. Invited by Embry-Riddle Aeronautical University – Worldwide College of Arts and Sciences Brown Bag Lunch & Learn Series.
- [**2 - National Conference Presentation**] Faulconer, E., Chamberlain Jr., D., & Wood, B. (2022, April 13). Instructional Efficiency in Asynchronous Online Discussions. Online Learning Consortium Innovate Conference, Dallas, TX.
- [**1 - External Grant**] Co-Principal Investigator, NSF IUSE: Community of Inquiry and Cognitive Load in Online STEM: Persistence, Performance, and Perspectives, with Emily Faulconer (PI) and Beverly Wood (co-PI). 2021-2024. Award amount: $233,298.

Co-PI: *Undergraduate Research for Fully Online STEM Students: Impact of Expanded Curricular Options on STEM Attitudes, Identity, & Career Ambitions*

Research Team:

Robert Deters (PI), Emily Faulconer (co-PI), Brent Terwilliger (co-PI)

Funding Source:

Externally funded through NSF, 10/16/23–10/15/26

Roles:

Grant Writing, Curriculum Development, Workshop Development and Management, Data Collection, Data Management, Data Analysis, Manuscript Writing, Dissemination

Brief Description by Year

AY 21-22 N/A - was not part of research team.

AY 22-23 Brought on to replace previous data expert on NSF project in January 2023. Participated in drafting the NSF grant before submission. Participated in responding to NSF program officer with comments.

AY 23-24 Project formally begins in October 2023. However, I have been included as the data analyst on a paper from the previous NSF grant this project is continuing. The paper, *Virtual Mentorship for Online Undergraduate Research: Analysis of Mentors and Mentees' Perspectives*, has been submitted to the Journal of Experiential Education in October 2023. I wrote the methodology, data analysis approach, results, and part of the discussion for this paper. It is not included in the Record of Activities as it has not yet been accepted.

Scholarly Products:

- [**1 - Journal Article**] Faulconer, E., Terwilliger, B., Chamberlain Jr., D., Deters, R., & Kam, C. (under review Oct 2023). Virtual Mentorship for Online Undergraduate Research: Analysis of Mentors and Mentees' Perspectives. Journal of Experiential Education.

Internally-Funded Research Projects

PI/Co-PI: *Collective Knowledge Progression and Proliferation in Asynchronous Calculus Discussion Boards*

Research Team:

Zackery Reed (PI/Co-PI) and Karen Keene (co-PI posthumous)

Funding:

Internally through ERAU-W Faculty SEED grant, 2/1/23–6/31/23.

Roles:

All aspects of the project in equal parts with collaborators. PIs Chamberlain and Reed take turns leading parts of the project.

Brief Description by Year

AY 21-22 Shortly after starting at ERAU-W, the three collegiate mathematics education researchers in the department of Mathematics, Science, and Technology formed a mathematics eduation research group. After exploring and negotiating what we would work on, we decided to work on how students develop knowledge in ERAU-W discussions. We also agreed to work as equal collaborators as we all had similar research skills. We presented our initial theoretical framework first at a regional conference [**1**], then at a national conference [**2**]. Unfortunately due to Dr. Keene's health, she stepped away from the project in Febuary 2022 to recover. Dr. Reed and I took preliminary data available from Dr. Reed's course to iteratively apply and refine our theoretical framework.

AY 22-23 After Dr. Keene recovered and rejoined the group in August 2022, we again negotiated the refinements of the theoertical framework. We applied to and were awarded an internal grant [**3**] to formally collect data and hire undergraduate researchers to apply our theoretical framework to the data. Dr. Keene suddenly passed in February 2023 just before our research group hosted a national conference workshop [**4**] as well as presented key preliminary insights to the new theoretical framework [**5**]. Continuing with the data collected and analyzed from the internal SEED grant, Dr. Reed and I submitted an abstract for a book chapter [**6**] on Teaching and Learning Mathematics Online. This abstract was accepted in July 2023.

AY 23-24 Dr. Reed and I will continue to work on the Book Chapter [**6**] as well as analyze the data collected as part of the internal SEED grant. We are actively recruiting an additional researcher to join the project before submitting for external funding.

Scholarly Products

- [**6 - Book Chapter**] Reed, Z. & Chamberlain Jr., D. (abstract submitted Mar 2023, accepted for chapter submission Jul 2023). A Framework for Analyzing Asynchronous Discussion Activities. Teaching and Learning Mathematics Online 2e, CRC Press, FL.
- [**5 - National Conference Proceeding**] Chamberlain Jr., D., Reed, Z., & Keene, K. (2023, Feb 23-25). Adapting the Argumentative Knowledge Construction Framework to Asynchronous Mathematical Discussions. Proceedings of the 25th Annual Conference on Research in Undergraduate Mathematics Education: SIGMAA on RUME, Omaha, NE.
- [**4 - Conference Workshop Organization**] Chamberlain Jr., D., Reed, Z., & Keene, K. (2023, Feb 23). Workshop: Research on Technology in Undergraduate Mathematics Education. 25th Annual Conference on Research in Undergraduate Mathematics Education: SIGMAA on RUME, Omaha, NE.

- **[3 - Internal Grant]** Principal Investigator, ERAU-W Faculty Seed Grant: Collective Knowledge Progression and Proliferation in Asynchronous Calculus Discussion Boards, with Zackery Reed (co-PI) and Karen Keene (co-PI). 2023. Award amount: $6,000.
- **[2 - National Conference Proceeding]** Reed, Z., Chamberlain Jr., D., & Keene, K. (2022, Feb 24-26). Argumentative knowledge construction in asynchronous calculus discussion boards. Proceedings of the 24th Annual Conference on Research in Undergraduate Mathematics Education: SIGMAA on RUME, Boston, MA. URL: http://sigmaa.maa.org/rume/RUME24.pdf.
- **[1 - Regional Conference Presentation]** Chamberlain Jr., D., Reed, Z., & Keene, K. (2021, Nov 20). Investigating social construction of knowledge during asynchronous discussions. 5th Northeastern Conference on Research in Undergraduate Mathematics Education. New Brunswick, NJ (virtual).

PI: *Undergraduate Covariational Reasoning in Calculus*

Research Team:

Teegan Bailey (undergraduate co-PI), Konstantina Christodoulopoulou (co-PI)

Funding Source:

Internal (to University of Florida) support for undergraduate research, 2021-2023.

Roles:

Faculty advisor, manuscript writing

Brief Description by Year

AY 21-22 Before joining ERAU-W, I served as Teegan Bailey's faculty research advisor. While Dr. Christodoulopoulou formally became Bailey's advisor, I continued mentoring Bailey. We meet at least once every two weeks to discuss mathematics education theory and/or progress in his research project. This led to his first presentation and publication **[1]**.

AY 22-23 Dr. Christodoulopoulou took a primarily role in guiding Bailey with collecting data for his second research project. While data was collected, Bailey began applying to graduate programs outside of collegiate mathematics education and thus discontinued working on the research. This project is now complete.

Scholarly Products

5. **[National Conference Proceeding]** Bailey, T., Chamberlain Jr., D., & Christodoulopoulou, K. (2022, Feb 24-26). Undergraduate's covariational reasoning across function representations. Proceedings of the 24th Annual Conference on Research in Undergraduate Mathematics Education: SIGMAA on RUME, Boston, MA. URL: http://sigmaa.maa.org/rume/RUME24.pdf.

Scholarly Products not Associated to an Active Research Project

Project NExT Activities

Brief Description

As part of the professional development fellowship Project NExT (New Experiences in Teaching), I organized special sessions at two different mathematics education conferences: Joint Mathematics Meeting 2023 and Mathematics Association of America MathFest 2023. Each session consisted of 2-3 panelists answering pre-prepared questions as well as spontaneous audience questions. I acted as the lead organizer for all three sessions.

Scholarly Products

- **[Conference Session Organization]** Chamberlain Jr., D. & Barber, R. (2023, Aug 2). Session: Unspoken Research Components. 2023 MAA MathFest, Tampa, FL.

- [**Conference Session Organization**] Chamberlain Jr., D. & Barber, R. (2023, Aug 2). Session: Building a Research Program. 2023 MAA MathFest, Tampa, FL.
- [**Conference Session Organization**] Chamberlain Jr., D., Acu, B., & Gasiorek, S. (2023, Jan 3). Session: Navigating the Early Years of the Faculty Experience. 2023 Joint Mathematics Meeting, Boston, MA.

Presentations as an Expert in the Field

Brief Description

Collaborators for a project I was once a part of presented [**1**] at a national conference. I acted as a data analytics expert for the University of Florida graduate student, Sam Vancini, that has taken over the data analysis postition I previously provided. My involvement in this project is complete as of AY 21-22.

I have also spoken as an expert to students about non-traditional scholarly publication [**2**], as an expert in online education [**3**], and as the chair of the Mathematics Association of America Subcommittee on Technology in Mathematics Education [**4**].

Scholarly Products

- [**4 - National Conference**] Chamberlain Jr., D. (2023, Aug 2). Technology Use in Undergraduate Mathematics Classrooms. 2023 MAA MathFest, Tampa, FL.
- [**3 - Regional Conference**] Chamberlain Jr., D., Reed, Z., Rister, A., & Velez, M. (2023, Feb 7). Roundtable discussion: Practical Suggestions to Improve Online Discussions Across Disciplines. 2023 Academic Innovation Virtual Conference hosted by ERAU-W.
- [**2 - Local Presentation**] Faulconer, E., Bourdeau, D., Kiernan, K., & Chamberlain Jr., D. (2023, Jan 21). Non-Traditional Scholarly Publication. Invited by Embry-Riddle Aeronautical University – Worldwide Research Scholars Program.
- [**1 - National Conference**] Paolucci, C., Chamberlain Jr., D., & Vancini, S. (2022, Apr 7). Investigating alternatively-certified teachers' mathematical knowledge for teaching calculus. Joint Mathematics Meeting, Seattle, WA.