

# SARAH CASTLE

MICHIGAN STATE UNIVERSITY  
Program in Mathematics Education  
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## EDUCATION

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- Ph.D.** *Michigan State University*, Program in Mathematics Education June 2023  
Dissertation: *Exploring the Effects of Computing Enacted Through Coding on Students' Mathematical Creativity and Understanding*  
Committee: Dr. Shiv Smith Karunakaran (chair), Dr. Danny Caballero, Dr. Jennifer Green, Dr. Vince Melfi, & Dr. Devin Silvia
- M.S.** *Michigan State University*, Mathematics December 2022
- B.S.** *Whitworth University*, Engineering Physics and Mathematics May 2016  
Minored in French, Summa Cum Laude

## HONORS AND AWARDS

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- College of Natural Science Dissertation Continuation Fellowship, \$7500 2022
- Dr. Marilyn Zweng Endowed Graduate Student Award in Mathematics Education, \$3250 2022
- SEISMIC Measurement Fellowship, \$5000 2021
- Michigan State University Distinguished Fellowship 2018
- Michigan State University College of Natural Science Recruiting Fellowship 2018
- Department of Energy Computational Science Graduate Fellowship 2016
- Princeton University Gordon Y.S. Wu Fellowship 2016
- Whitworth University Mathematics and Computer Science Research Award, \$300 2016
- American Physical Society Division of Plasma Physics Student Participation and Travel Grant, \$800 2015

## PUBLICATIONS

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**Castle, S. D.** (Accepted) Leveraging Computational Science Student's Coding Strengths for Mathematics Learning. In *54th ACM Technical Symposium on Computer Science Education*

**Castle, S. D.** (2022). If Creativity Return Computing: Exploring the Impact of Computing on Students' Mathematical Creativity in Linear Algebra. In *Proceedings of the 2022 ACM Conference on International Computing Education Research-Volume 2* (pp. 24-25).

Pearson, M. I., **Castle, S. D.**, Matz, R. L., Koester, B. P., & Byrd, W. C. (2022). Integrating Critical Approaches into Quantitative STEM Equity Work. *CBE—Life Sciences Education*, 21(1)

Hwang, J., **Castle, S. D.**, & Karunakaran, S. S. (2022). One is the Loneliest Number: Groupwork within Linguistically Diverse Classrooms. *PRIMUS*, 1-13.

**Castle, S. D.**, Smith III, J. P., Levin, M., Hwang, J., Karunakaran, S. S., Küchle, V., & Elmore, R. (2022). Shifts in External Authority and Resources for Sense-making in the Transition to Proof-Intensive Mathematics: The Case of Amelia. In Karunakaran, S. S., & Higgins, A. (Eds.). *Proceedings of the 24th Annual Conference on Research in Undergraduate Mathematics Education*. (pp.100-107) Boston, MA

**Castle, S. D.**, Byrd, W. C., Koester, B. P., Boenem, E., Caporale, N., Cwik, S., Denaro, K., Denaro, D., Fiorini, S., Matz, R., Mead, C., Whitcomb, K., Singh, C., Levesque-Bristol, C., & McKay, T. (2021) Equity in the STEM Landscape: A Multi-Institutional Approach to Mapping Systemic Advantages Within STEM Courses, *2021 American Education Research Association Annual Meeting Proceedings* <https://doi.org/10.3102/1689325>

**Castle, S. D.**, (2021) Connecting Computation: Mediating Mathematical Knowledge Through Computational Modules, In Karunakaran, S. S., & Higgins, A. (Eds.). *2021 Research in Undergraduate Mathematics Education Reports*. (pp.30-38)

Levin, M., Smith III, J. P., Karunakaran, S. S., Küchle, V., **Castle, S. D.**, Hwang, J., Elmore, B., Bae, Y. (2020). Math and Moral Reasoning in the Age of the Internet: Undergraduate Students' Perspectives on the Line Between Acceptable Use of Resources and Cheating, In Karunakaran, S. S., Reed, Z. & Higgins, A. (Eds.). *Proceedings of the 23rd Annual Conference on Research in Undergraduate Mathematics Education*. (pp.366-373) Boston, MA

Smith III, J. P., Küchle, V., **Castle, S. D.**, Karunakaran, S. S., Bae, Y., Hwang, J., Levin, M., Elmore, B. (2020). Dimensions of Variation in Group Work within the "Same" Multi-Section Undergraduate Course. In Karunakaran, S. S., Reed, Z. & Higgins, A. (Eds.). In *Proceedings of the 23rd Annual Conference on Research in Undergraduate Mathematics Education*. (pp.606-613) Boston, MA

Levin, M., Smith, J. P., Karunakaran, S., Küchle, V. A., & **Castle, S. D.** (2020). Conceptualizing STEM Majors' Developing Agency and Autonomy in Undergraduate Mathematics. In Gresalfi, M. and Horn, I. S. (Eds.), *The Interdisciplinarity of the Learning Sciences*, 14th International Conference of the

Learning Sciences (ICLS) 2020, Volume 2 (pp. 887-888). Nashville, Tennessee: International Society of the Learning Sciences.

Sankaran, K., French, A., **Gady, S.**, Wisniewski, T., & Woodkey, M. (2014). Evaluation of Electric Propulsion Systems for Asteroid and Comet Sample-Return Missions. In *50th AIAA/ASME/SAE/ASEE Joint Propulsion Conference* (p. 3720). <https://doi.org/10.2514/6.2014-3720>.

### ***Other Manuscripts***

**Gady, S.**, & Munson, T. (2017). Stochastic Cogeneration System Design Applied to University Campus. ANL MCS Internal Report

### ***Submitted Manuscripts***

**Castle, S. D.** (2022) Exploring How Computation Can Foster Mathematical Creativity in Linear Algebra Modules. Submitted to 2023 SIGMAA on RUME Conference

### ***Manuscripts in Progress***

**Castle, S. D.**, (In Preparation) The Case for Computing: How Computation has the Potential to Reinvigorate Mathematical Creativity. Submitting to FLM

**Castle, S. D.**, (In Preparation) Creation and Computation: A Series of Linear Algebra Jupyter Notebooks Designed to Promote Mathematical Creativity. Submitting to The Journal of Open-Source Education

**Castle, S. D.**, Pearson, M. I., Byrd, W. C., Koester, B. P., Boenem, E., Caporale, N., Cwik, S., Denaro, K., Denaro, D., Fiorini, S., Matz, R., Mead, C., Sweeder, R., Singh, C., Levesque-Bristol, C., & McKay, T. (In Preparation) Foregrounding Systems and Structures of Inequity: A Multi-Institutional Analysis Examining Systemic Advantage Manifestation Within Introductory STEM Courses

## **PRESENTATIONS**

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### ***Refereed Conference Presentations***

*\*Denotes presenter*

Hwang, J.\*, **Castle, S. D.\***, Karunakaran, S. S.\* (2023, January 4-7) *Two students' groupwork experiences in a linguistically diverse classroom* [Abstract Presentation], 2023 Joint Mathematics Meetings: Boston, MA.

**Castle, S. D.\*** (2022, August 7-10). *If Creativity Return Computing: Exploring the Impact of Computing on Students' Mathematical Creativity in Linear Algebra* [Abstract Presentation]. 2022 ACM Conference on International Computing Education Research, Lugano, Switzerland.

Sweeder, R. \*, **Castle, S. D.**, Koester, B. P., Byrd, W. C.; Pearson, M.; Boenem, E., Caporale, N., Cwik, S., Denaro, K., Fiorini, S., Levesque-Bristol, C.; Matz, R., Mead, C., Brownell, S., Molinaro, M., Singh, C., McKay, T. (2022, March 20-24) *Exposing inequity: A multi-institutional analysis of systematic advantages in introductory STEM courses* [Abstract Presentation]. ACS (American Chemical Society) Spring 2022 National Meeting, San Diego, CA.

**Castle, S. D.\***, Smith III, J. P., Levin, M., Hwang, J., Karunakaran, S. S., Kuchle, V., & Elmore, R. (2022, February 24-26). *Shifts in External Authority and Resources for Sense-making in the Transition to Proof-Intensive Mathematics: The Case of Amelia* [Paper Presentation]. 24th Annual Conference on Research in Undergraduate Mathematics Education, Boston, MA

**Castle, S. D.\***, Byrd, W. C., Koester, B. P., Boenem, E., Caporale, N., Cwik, S., Denaro, K., Denaro, D., Fiorini, S., Matz, R., Mead, C., Whitcomb, K., Singh, C., Levesque-Bristol, C., & McKay, T. (2021, April 8-12) *Equity in the STEM Landscape: A Multi-Institutional Approach to Mapping Systemic Advantages Within STEM Courses* [Paper Presentation], 2021 American Education Research Association Annual Meeting

Levin, M. \*, Smith III, J. P., Karunakaran, S. S., Kuchle, V., **Castle, S. D.**, (2021). *Conceptualizing Agency and Autonomy in Tertiary Mathematics* [Abstract Presentation], In 14<sup>th</sup> International Congress on Mathematical Education Conference Proceedings.

Caporale, N. \*, **Castle, S. D.\***, Denaro, K. (2020, November) *Developing Multi-institutional Collaborations in Student Analytics* [Poster Presentation], AAC&U Transforming STEM Higher Education, Virtual.

Levin, M., Smith III, J. P., Karunakaran, S. S., Kuchle, V., **Castle, S. D.\***, Hwang, J., Elmore, B., Bae, Y. (2020). *Math and Moral Reasoning in the Age of the Internet: Undergraduate Students' Perspectives on the Line Between Acceptable Use of Resources and Cheating* [Paper Presentation], 23<sup>rd</sup> Annual Conference on Research in Undergraduate Mathematics Education, Boston, MA.

Smith III, J. P. \*, Kuchle, V., **Castle, S. D.**, Karunakaran, S. S., Bae, Y., Hwang, J., Levin, M., Elmore, B. (2020). *Dimensions of Variation in Group Work within the "Same" Multi-Section Undergraduate Course* [Paper Presentation]. 23<sup>rd</sup> Annual Conference on Research in Undergraduate Mathematics Education, Boston, MA.

Levin, M.\*, Smith III, J. P., Karunakaran, S. S., Kuchle, V. A., & **Castle, S. D.** (2020, June 19-23). *Conceptualizing STEM Majors' Developing Agency and Autonomy in Undergraduate Mathematics* [Paper Presentation], 14th International Conference of the Learning Sciences (ICLS).

**Gady, S.\*** (2019, February 28 - March 2). *Integrating Integration: Deepening Mathematical Understanding Through Computation* [Abstract Presentation], 22<sup>nd</sup> Annual Conference on Research in Undergraduate Mathematics Education, Oklahoma City, OK.

**Gady, S.\***, Kubota, S., & Johnson, I. (2015, November 16-20). *Comparison of a 3-D GPU-Assisted Maxwell Code for Synthetic Diagnostics on ITER* [Poster Presentation], 57<sup>th</sup> Annual Meeting of the APS Division of Plasma Physics, Savannah, GA.

Sankaran, K.\*, French, A., **Gady, S.**, Wisniewski, T., & Woodkey, M. (2014, July 28-30). *Evaluation of Electric Propulsion Systems for Asteroid and Comet Sample-Return Missions* [Paper Presentation]. 50th AIAA/ASME/SAE/ASEE Joint Propulsion Conference, Cleveland, OH.

French, A.\*, **Gady, S.\***, & Sehgal, A.\* (2014, May 1-3). *Evaluation of Electric Propulsion Systems for Asteroid Sample-Return Missions* [Poster Presentation], Annual Meeting of the Northwest Section of the APS, Seattle, WA.

### ***Other Presentations***

**Castle, S. D.\*** (2022, June) Exploring the Impact of Computing on Students' Mathematical Creativity, University of Oslo Physics Education Research Summer Institute, Oslo, Norway

**Castle, S. D.\*** (2021, November) Systemic Advantages Within Introductory STEM Courses, University of Pittsburgh dB-SERC Colloquium, Pittsburgh, PA.

Matz, R.\*, Fiorini, S.\*, Caporale, N.\*, **Castle, S. D.\***, Fisher, C.\* (2021, May) Analytics to support student success in STEM: *Stories from the Sloan Equity and Inclusion in STEM Introductory Courses (SEISMIC) Measurement Working Group* [Panel Presentation], Indiana University Learning Analytics Summit, Bloomington, IN.

**Gady, S.\*** (2014, September). Modeling Astronaut Central Nervous System Cerebral Fluid Response to Microgravity and Its Effects on Astronaut Vision, Spokane Mathematics Colloquium, Spokane, WA.

## MEMBERSHIP IN PROFESSIONAL SOCIETIES

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### **American Education Research Association (AERA)**

Div J - Postsecondary Education

Research in Mathematics Education

Technology as an Agent of Change in Teaching and Learning

### **Association for Computing Machinery (ACM)**

Special Interest Group Computer Science Education

### **Computer Science Teachers Association (CSTA)**

### **Mathematical Association of America (MAA)**

SIGMAA on Research on Undergraduate Mathematics Education

### **Society for Industrial and Applied Mathematics (SIAM)**

SIAG on Applied Mathematics Education

SIAG on Computational Science and Engineering

## RESEARCH EXPERIENCE

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*Summary:* My primary research interest is focused on the integration of mathematics and computation at the undergraduate level while maintaining an eye towards equity. My dissertation research has focused on how computation can serve as a pedagogical tool to promote mathematical creativity within the context of linear algebra. My additional research centered on student experiences in the transition to proof within undergraduate mathematics has leveraged the concepts of agency and autonomy which are reflected in my current conception of computation for mathematical creativity. Further, my own experiences in research combining computation, mathematics, and engineering highlight a unique scholarly positioning to be able to speak to the application and benefit of computation in a mathematics program.

### **SEISMIC Collaboration Research Member**

2020 to Present

Developed code and theoretical frameworks to analyze institutional data regarding student experiences and systemic inequities that manifest in introductory STEM courses, specifically with an eye towards intersectionality

### **Transition to Proof Research Assistant, Michigan State University**

2018 to Present

As part of an NSF funded grant documented student experiences within an introduction to proof course through classroom observations, surveys, interviews, and task-based interviews in order to develop frameworks for student's mathematical agency and autonomy development

### **CERL Research Member, Michigan State University**

2018, 2021-Present

Analyzed relationship between computational thinking and mathematical thinking within the context of integration through task-based interviews with students who had completed an introduction to modeling course

- Research Intern, Argonne National Laboratory** 2017  
Developed mixed integer linear program with uncertainty for optimization of cogeneration, performed extensive data processing and formatting with raw data and clustered the data using various k-clustering methods
- Research Intern, Princeton Plasma Physics Laboratory** 2015  
Aided in development of 3-D GPU-assisted Maxwell code for reflectometry synthetic diagnostics on ITER by performing domain decomposition to allow for analysis of an ITER-sized plasma
- NASA Space Academy Intern, NASA Glenn Research Center** 2014  
Developed an integrated model of the cardiovascular and central nervous systems for use in analysis of microgravity induced fluid redistribution through a computational simulation of model within MATLAB and performed validation and verification tests in order to ensure accuracy
- Research Intern, Whitworth University** 2013  
Advanced computational simulation of plasma propulsion systems for interplanetary spacecraft and improved previous code to allow for simulation of mission to any near-earth object and implemented engine shutoff during mission simulation

## **TEACHING EXPERIENCE**

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*Summary:* At the undergraduate level, I have teaching experience as (1) an instructor of record with full responsibility for teaching the class, grading, writing assessments and assignments, developing interactive computational exercises, etc. (2) private and volunteer tutor (middle school to post-secondary), and (3) teaching assistant for the instructor of record where I graded materials, lead recitations, and held office hours.

**Michigan State University** 2020-2022  
Instructor of Record, *Mathematics Department*

Taught Elementary Mathematics for Teachers I (MTH 201), Calculus I (MTH 132), Survey of Calculus II (MTH 126)

Developed interactive materials and curriculum to engage students in mathematical exploration and foster mathematical creativity within the classroom

**Mead School District** 2016  
Instructor, *Summer STEM Academy*

Developed week-long, hands-on STEM modules and curriculum for 5<sup>th</sup>-7<sup>th</sup> grade students and was lead instructor on a high-altitude balloon launch for testing of near space phenomena and co-instructor and developer for coding and gaming module

**Whitworth University** 2012-2016  
S.I. Instructor, *Engineering and Physics Department*

Led weekly supplemental instructions session to reinforce physics concepts by developing assignments and resources and held weekly office hours to assist students with homework, and ran review sessions prior to tests  
Grader and Teaching Assistant, *Mathematics and Computer Science Department*  
Teaching assistant for Calculus II, Calculus for Social Sciences, Discrete Mathematics, and Mathematical Statistics I and II

## **PROFESSIONAL SERVICE**

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**SEISMIC Collaboration Council Member**, 2022 – Present  
Measurement Working Group Representative

**SEISMIC Collaboration Taskforce Member**, 2021  
Conducted structural work for the SEISMIC collaboration to examine existing collaboration structures in order to redress harm and focus on promoting diversity and inclusion

**MSU PRIME Colloquium Committee Member**, 2019 – 2021

## **OTHER SERVICE**

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**Graduate Women in Science (GWIS) Mentor**  
Michigan State University, 2022 – Present

**PRIME Graduate Student Organization Officer**  
Michigan State University, 2019 – 2021

**Graduate Student Representative**  
Princeton University, 2017-2018

**Science Outreach Volunteer**  
Princeton University, 2016-2018

**Math is Cool Organizer and Volunteer**  
Spokane WA, 2012-2016

**National Science Bowl Proctor**  
Spokane WA, 2015-2016, 2021

**Physics Outreach Volunteer**  
Whitworth University, Spokane WA, 2013-2016

## **GRADUATE COURSEWORK**

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***Michigan State University (Mathematics and Computational Science)***  
Complex Analysis, Real Analysis, Graph Theory, R Programming for Data Science,  
Numerical Analysis, Numerical Methods Ordinary Differential Equations, Partial Differential



Equations I & II, Readings in Mathematics: Hermite Methods, Introduction to Computational Modeling, Methods in Computational Modeling, Combinatorics

***Princeton University (Computational Aerospace Engineering)***

Mathematical Methods of Engineering Analysis I & II, Automatic Control Systems, Advanced Dynamics, Advanced Orbital Mechanics, Optimal Control and Estimation, Linear and Nonlinear Optimization

***Michigan State University (Education)***

Proseminar in Mathematics Education, Introduction to Qualitative Research, Design and Methods in Mathematics Education Research, Critical Content School Mathematics Algebra, Quantitative Methods in Education Research I & II, Special Topic: Statistics Education, Programming Concepts in K-12 Education, Creativity in K-12 Computing Education, Teaching College Mathematics, Mathematical Ways of Knowing, Phenomenology