

# **The Impact of Instructional Environment, Student Behaviors, and Instructor Behaviors on Calculus I Students' Math Anxiety While Learning via Inquiry-Based Learning**

**Harman P. Aryal**  
Stockton University

Friday August 9, 2024

MAA MathFest  
Indianapolis, IN

# Background & Motivation

- Taught high school mathematics for about 17 years
- Interaction with students showed their aversion toward math
- A national inquiry-based learning (IBL) conference in 2018 triggered my interest in IBL as a way to reduce math anxiety.
- Further involvement in IBL led me to conduct my dissertation project in this area
- Today, I am presenting some of my dissertation research findings.

# Research Questions

- What were the students' experiences and perceptions of taking Calculus I via IBL or lecture-based instruction?
- How do their' experiences and perceptions of taking Calculus I via respective instructional approaches influence their math anxiety?

# Math Anxiety

## What is math anxiety?

Math anxiety is characterized as feelings of tension and anxiety that interface with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations.

(Richardson & Suinn, 1972, pp. 551)

Math anxiety is “the panic, paralysis, and mental disorientation that arises among some people when they are required to solve a mathematical problem.

(Tobias and Weissbrod, 1980)

Math anxiety is an emotion that hinders the reasoning ability of an individual when encountering a mathematical situation.

(Spicer, 2004)

# Math Anxiety

## What are its symptoms?

- **Physical:** Sweaty palms, heart racing, restlessness, nail-biting
- **Mental:** Intrusive thoughts, mind blanking, inability to concentrate
- **Emotional:** Apprehension, lack of confidence, extreme nervousness  
(e.g., Ashcraft, 2002; Chang & Beilock, 2016; Plaisance, 2009)

## What are its consequences?

- Avoidance of math and math-related activities
- Poor mathematics performance
- Lowered self-esteem and confidence
- Psychological distress

(e.g., Richardson & Suinn, 1972; Laursen & Rasmussen, 2019; Chang & Beilock, 2016)

# Four Pillars of IBL

	Mathematical Space	Social Space
Student Behavior	1. Engage deeply with meaningful tasks	2. Collaborate with classmates in processing ideas
Instructor Behavior	3. Inquire into student thinking and reasoning	4. Foster equity, respect, and responsibility

(cf. Laursen & Rasmussen, 2019; White et al., 2020)

# Participants

<b>Quantitative Participants</b>	
15 students from IBL group 20 from lecture-based group	Responded to pre- and -post-MARS survey
<b>Qualitative Participants (Selected based on the pre- to -post-test anxiety score change)</b>	
<i>IBL Group</i>	<i>Lecture-Based Group</i>
3 students—greatly increased	1 student—greatly increased
3 students—stayed the same	1 student—stayed the same
3 students—greatly decreased	1 student—greatly decreased

# Data Collection and Analysis

## Data Collection

- MARS-S Survey  
Suinn & Winston (2003)
- Semistructured Interviews
- Class Observations

## Data Analysis

- Nvivo software for coding
- Thematic analysis



# Results

## Students' Perceptions and Experiences

<i>IBL Group</i>	<i>Lecture-Based Group</i>
<ul style="list-style-type: none"><li>• Felt more welcoming and sense of belonging</li><li>• Engaged in small group activities</li></ul>	<ul style="list-style-type: none"><li>• Felt somewhat welcoming, but no sense of belonging because of online environment</li><li>• Initiated and maintained out-of-class collaboration</li></ul>
<ul style="list-style-type: none"><li>• Instructor-student talk time ratio was 22:33 min</li><li>• Optional HW and pretasks that were not graded</li></ul>	<ul style="list-style-type: none"><li>• Instructor-student talk time ratio was 53:2 min</li><li>• Too many and mandatory HW problems that were graded</li></ul>
<ul style="list-style-type: none"><li>• Sought for the extra support from the instructor</li><li>• Felt more confident and empowered</li></ul>	<ul style="list-style-type: none"><li>• Sought for the extra support from the recitation instructor</li><li>• Felt moderately confident and empowered</li></ul>

# Results (Contd.)

## Activities That Reduced Students' Anxiety

### *IBL Group*

- Mixed learning environment
- In-class group activities
- Talking to their groupmates
- Welcoming and caring nature of the instructor
- Asking questions of the instructor outside of class
- Optional and ungraded HW
- Opportunity to resubmit the tests

### *Lecture-Based Group*

- Recitation classes
- Recorded lecture videos
- Out-of-class group work
- Instructor's readiness to reexplain the materials in class

# Results (Contd.)

<b>Activities That Increased Students' Anxiety</b>	
<i>IBL Group</i>	<i>Lecture-Based Group</i>
<ul style="list-style-type: none"><li>• Gradually accelerated course pace</li></ul>	<ul style="list-style-type: none"><li>• Fast paced teaching</li><li>• Too many Webwork problems</li></ul>
<b>Activities That Increased Both Groups' Anxiety</b>	
<ul style="list-style-type: none"><li>• Tests and quizzes</li><li>• Proctored-track exams</li><li>• Instructor's questions</li><li>• Thinking of being called on by the instructor in class</li><li>• Responding to the instructor's questions in front of their classmates</li></ul>	

# Student Quotes

## **IBL Group**

*I think doing the task in a group reduced it (anxiety) for sure...*

*I would definitely say I don't enjoy going to class because I'm scared, he's going to call on me and ask me a question I don't know the answer to.*

## **Lecture-Based Group**

*I was a little stressed out because he would call on people, and I was scared that he would call on me.*

*In the group meet ... if they (colleagues) have questions, they just ask. And then, there would be the one person that would either respond, or they won't if it's not easy.*

# References

- Ashcraft, M. H. (2002). Mathematics anxiety: Personal, educational, and cognitive consequences. *Current Directions in Psychological Science, 11*(5), 181–185.
- Chang, H., & Beilock, S. L. (2016). The mathematics anxiety-math performance link and its relation to individual and environmental factors: A review of current behavioral and psychophysiological research. *Current Opinion in Behavioral Science, 10*, 33–38.
- Laursen, S. L., & Rasmussen, C. (2019). I on the prize: Inquiry approaches in undergraduate mathematics. *International Journal of Research in Undergraduate Mathematics Education, 5*, 129–146.
- Plaisance, D. V. (2009). A teacher's quick guide to understanding mathematics anxiety. *Louisiana Association of Teachers of Mathematics Journal, 6*(1), 1–8.
- Richardson, F. C., & Suinn, R. M. (1972). The mathematics anxiety rating scale: psychometric data. *Journal of Counseling Psychology, 19*(6), 551–554.
- Suinn, R.M., & Winston, E. H. (2003). The mathematics anxiety rating scale, a brief version: Psychometric data. *Psychological Reports, 92*(1), 167–173.
- White, N., Wilson, R. T., & Jones, M. (2020, July). An introduction to (online) inquiry-based learning [Webinar]. *Mathematical Association of America*. <https://www.youtube.com/watch?v=W8cp4UFHaS0>

# Questions, Comments, & Discussions?

Harman Aryal: [harman.aryal@stockton.edu](mailto:harman.aryal@stockton.edu)