Using GSIs' Training as a Mechanism for Reform Efforts in the Mathematics Classroom

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Some Initial Definitions in PD from the RUME Community

- For us, we will use the term **TA** to mean those graduate students who are responsible running labs, recitations, grading etc.

- **Graduate Student Instructors** (GSIs) are those graduate students whose primary role is to serve as instructors of record for undergraduate students

- **Developers** are the faculty and/or academic staff who are responsible for providing training sessions/courses on undergraduate math ed/ etc.

- **Coordinators** are the faculty and/or academic staff who oversee the fundamentals of managing the day-to-day operations of particular course and who work closely with the instructors for those courses (both faculty/ academic staff and GSIs) they are responsible for coordinating

- **Professional Development (PD)** is any amalgam of *targeted* learning experiences for faculty/academics staff/TAs/GSIs to aid in their work as professional teachers: <u>includes</u> the work of developers <u>AND</u> coordinators!

Some Institutional Context

- 5 courses in the PreCalculus Program at UW Madison:
- MATH 96 – Intermediate Algebra (Remediation Course)
- MATH 141 - QR Course
- MATH 112 - College Algebra
- MATH 113 - Trigonometry
- MATH 114 - PreCalculus

Think About It

Think back to your graduate school days.

- What are things you believe would have been beneficial for you to be exposed to before you started teaching?
- Why those things?
- What are things that may have changed since you were a graduate student that you believe it might be important for today's graduate students to know before they enter the classroom?
- What kinds of learning opportunities do you think are important for GSIs as they are teaching?

Statement on Efforts to Reexamine and Revise Mathematics Education

Now more than ever, students need to develop their abilities in problem-solving, numerical reasoning, abstract thinking, and logical analysis so that they can fully participate in our quantitatively sophisticated society. The AMS supports open, inclusive, and civil discourse aimed at reexamining and, where needed, revising all levels of mathematics education. The AMS affirms that all students must have equitable access to high-quality programs that fully draw on and develop their mathematical capacities in contexts that engage students in the power, beauty, and relevance of mathematics.

MAA Practices Guide

The AMS statements reflect and amplify the Mathematical Association of America's (MAA) 2018 *Instructional Practices Guide* (IPG). The guide summarized research on effective methods of instruction.

- *design practices*
- *assessment practices*
- *classroom practices*

- The MAA has officially published and supports this document, the promotion of student-centered instructional methods is an expectation for departments moving forward.
- However, the IPG is a collection of recommended practices, not a syllabus for "methods for teaching." A tested curriculum for learning how to do and use the recommended practices does not yet exist.

American Mathematical Society
Policy Statement Regarding Career Teaching Faculty in Research Departments

Career teaching faculty in mathematics are an important part of the community of professional mathematicians. As experts focused on teaching, they add a great deal to their departments. They often play leading roles in the education of undergraduates, both non-majors and majors. They can be a source of innovations in curriculum and teaching, follow the literature around teaching and learning, and bring to their departments the latest innovations concerning these topics. They are often well prepared to sponsor independent studies for majors, supervise undergraduate research projects, and serve as departmental advisors for math majors. They may evaluate institutional data related to the teaching of math and undertake scholarship around the learning of mathematics. Math departments with career teaching faculty should value and support these faculty members as professional colleagues; they should encourage their institutions to develop pathways for the professional advancement of career teaching faculty, and to systematically support them in their career growth. The AMS supports career teaching faculty and strongly encourages their active participation in all activities of the society.

Impacts of PD on GSIs

- I really have valued my experience being observed and getting feedback about my teaching. And I know that not everyone feels that way, but, there are things that I feel like when people observe me and they say, you know, “I noticed that you do this or that” then I’m more aware of it. And there are things I think that I do subconsciously I don’t even realize. (Williams et al., 2021, p. 336)

Responsive teaching

- **Responsive teaching** is a student-centered approach in which teachers regularly elicit and use student productions (Roberson et al., 2016; Simon, 2022).
- In responsive classrooms, students are the drivers: they are the ones who produce the solutions to the questions that arise in classroom activity.
- Classroom discourse includes instructors asking students to justify their claims, students explaining their thinking to their neighbors, and each (teacher and student) taking stock of what they already know and think and how to use their existing knowledge (i.e., doing and responding to formative assessment).
- TA PD experiences that develop responsive student-centered MKT help to ensure the equitable outcomes called for by the mathematics professional community (Levin & Richards, 2011; Maskiewicz & Winters, 2012; Schoenfeld, 2016; Simon, 2022).
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Responsiveness to Students

Evidence-based Components of Responsive Student-Centered Instruction

- mathematical knowledge for teaching
- multiple representations of mathematical ideas
- attending to student thinking and using student ideas to push understandings forward
- positive classroom environment
- student-centered curriculum and methods to support students' learning how to:

1. learn 2. collaborate 3. evaluate knowledge claims 4. seek help
5. become (formative) assessment capable
6. be resilient (particularly in the face of cognitive challenges),
7. figure out what to do when they do not know what to do.

Table 1. Facets of student-centered instruction and valued types of knowledge
(Goodyear & Dudley, 2015; Otten et al., 2018).

Responsiveness to TAs and GSIs

I realized from my experiences that all the literature that we were reading was too general. In a sense it seemed to put every teacher under the same umbrella as if there was nothing that made us different. . . . It seemed as if they just wanted us to come in and just fit the American structure and follow that path. … I am an international teacher and I need to understand how I can bridge the gap between my own experiences with the experiences here and make that transition smoothly. (Bates Holland, 2008, p. 124)

Think About It

- What are important ideas for college algebra students to have a firm conceptual underpinning for the slope as an average rate of change?
- How might novice GSIs think about and teach the concept of average rate of change to a college algebra or a precalculus audience?
- What might the future consequences be (of say students taking Calculus 1) of how the GSIs present AROC?

Mathematical Knowledge for Teaching Understanding How GSIs Use Their Knowledge in Teaching

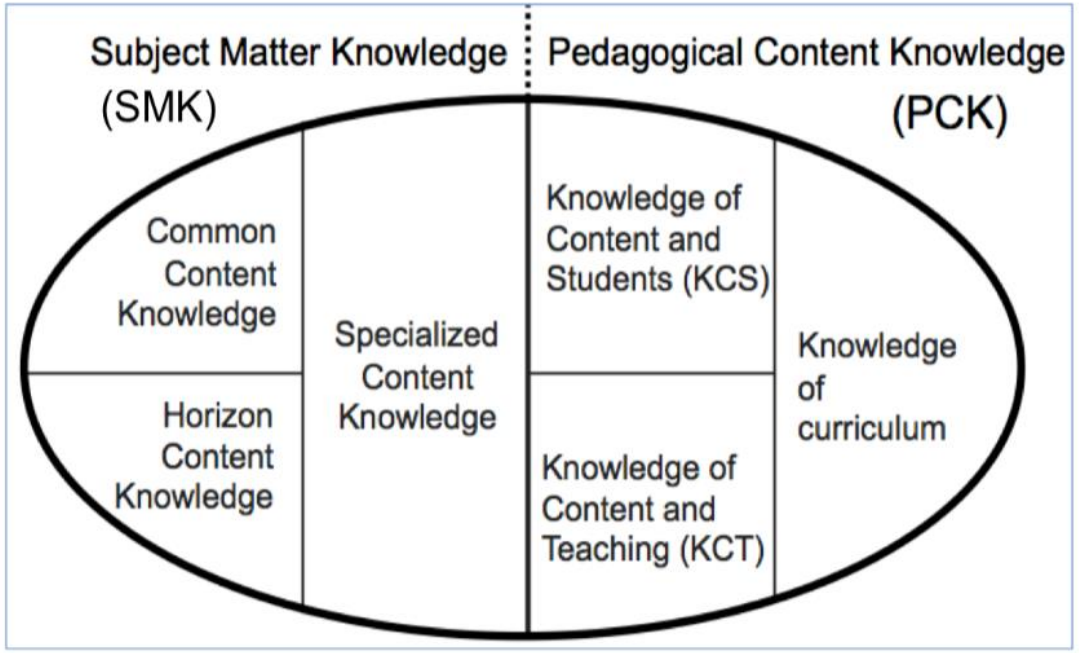


Figure 1: Domain map for MKT. Note that as this was initially conceptualized, epistemologically knowledge was given a post-positivist stance. Scheiner et al. (2019) provide a more socio-anthropological view of MKT.

Source: Hill, Ball, and Schilling (2008)

Carlson & Musgrave (2017)

Responses to the question: What does "average rate of change" mean to you?	
Alan:	A straight line between two points on a graph
Brian:	As one variable changes for every one unit, how much is the other variable changing. Slope.
Cassie:	Steepness of a graph, like how steep or how flat it is.
Diane:	Steepness of a graph. […] Uh, I don't have actual words.[…] Slope or derivative.
Edgar:	Rate of change over an interval
Frank:	The amount the dependent variable changes divided by the amount the independent variable changes. Delta y divided by delta x.
Greg:	I lost all the words…It's the predictive effect of changing one variable and the amount and how it's going to affect the other variable. One quantity affecting change in another quantity.

Figure 1. Pre-intervention participant descriptions of AROC

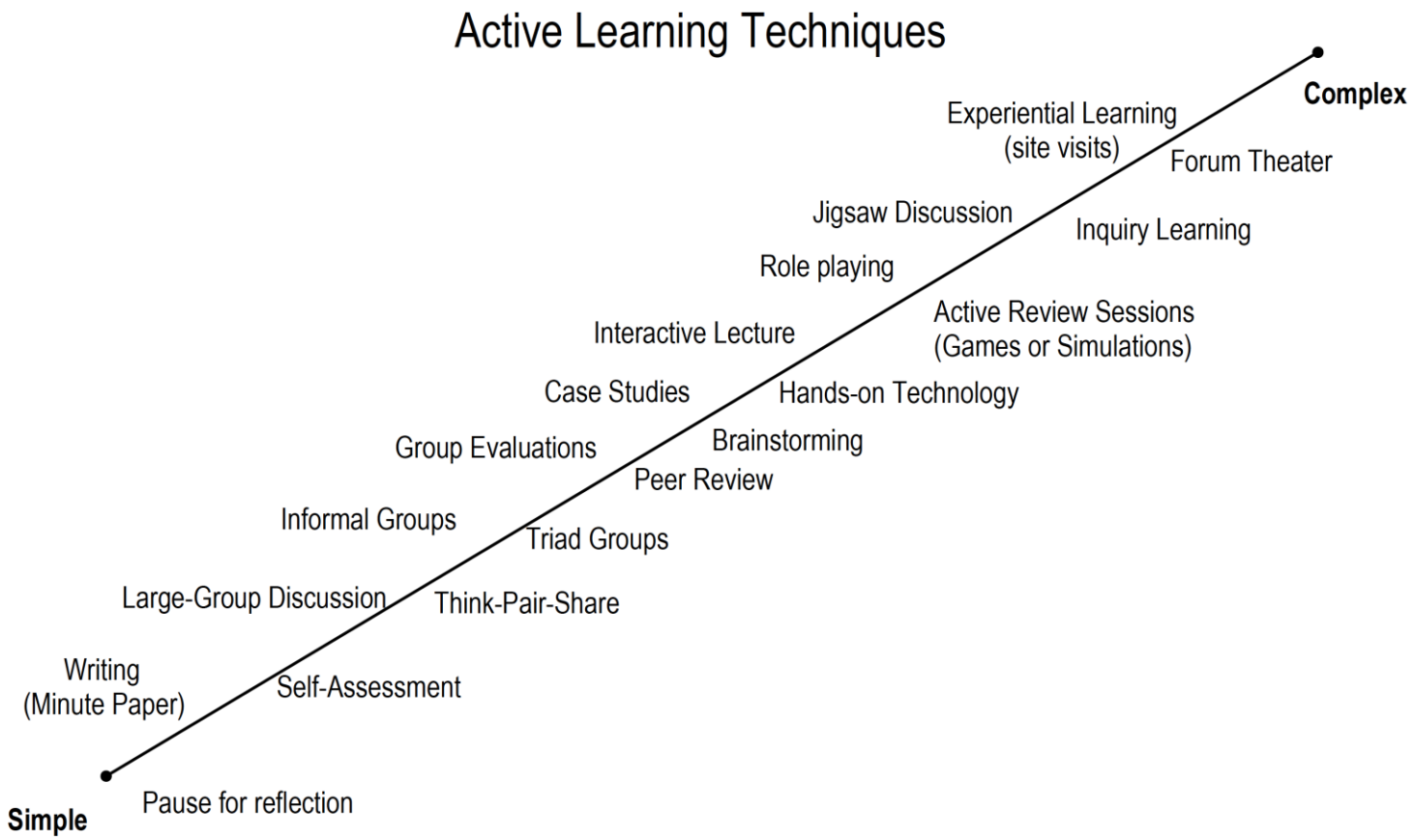
Carlson & Musgrave (2017)

Table 1. Experienced participant descriptions of AROC

Expressed Meaning Category	*Sample Excerpts from Clinical Interviews*	*Number of Instances**
Productive – General	[Students] have to understand constant rate of change because the average rate of change is the constant rate of change someone else would have to go, and I'm talking about average speed now, to achieve the same change in output for a given change in input. So, if you don't have meaning for constant rate of change, well, then average rate of change is just this number.	4
Average Speed	[AROC] is a constant rate of change for that specific time and distance, or uh, you know how I mean…	6
Conceptual Other	I would like to say linearization. Right, this idea of approximating something that isn't linear in a linear fashion.	1
Computational	… this final minus initial over the outputs and this final minus initial over the inputs and that's a rate.	2
Geometric	Average rate of change is the constant rate of change to go between two points.	2
Incorrect	I want my students to understand that constant rate of change is a special case, I guess of average rate of change. It's this special case that exists when the corresponding changes in our two quantities are proportional.	2
None		1

* Total exceeds 11 because some interviewees conveyed more than one expressed meaning

Responsiveness to GSIs



This spectrum arranges active learning techniques by complexity and classroom time commitment.

Prepared by Chris O'Neal and Tershia Pinder-Grover, Center for Research on Learning and Teaching, University of Michigan

Local Context at UW Madison

- 42% of Fall 2022 students tested into Precalculus Program (approximately 2300 students)
- 12 sections of 112 taught by GSIs at around 60 students and 2 peer mentors (about 800 students)
- Coordinator teaches section of 112 with about 110 students and 4 peer mentors
- 6 Sections of 113, one instructor and 3 GSIs (about 360 students)

Local Context at UW Madison

- Exams and quizzes are coordinated and graded by instructors (exams horizontally)
- 112 meets 3 days per week for 50 minutes in Cooperative Learning Spaces
- 113 meets 2 days per week for 50 minutes in Cooperative Learning Spaces
- 60-90 minute coordination meetings with coordinator each week: topics vary but do include attention to pedagogy frequently

Sample Notes in 112

REMARK:

We can write every quadratic function in its **vertex form** $f(x) = a(x-h)^2 + k$. The

coordinates of the vertex are at the point _____. As we noted above, when written

in vertex form, we can easily graph the quadratic functions because we can use transformations

on the graph of the function _____. To go from standard form to vertex form,

we saw in the previous activity on designing windows that we need to use the technique of

_____ _____ _____.

EXAMPLE 1:

Write the quadratic function $f(x) = 5x^2 - 10x + 15$ in vertex form and find the coordinates of the vertex. Is the vertex a max or a min? How do you know?

Sample Task in 112

Estimating our carbon *FOOD*print **Name(s) _____**

Did you know:

(1) that most food is produced by burning fossil fuels?

(2) That the fossil fuels burned each day to produce an average American's food emit about 12.69 pounds of carbon dioxide into the atmosphere? Over the course of a year, this is about 2.32 tons of carbon dioxide per person. (To put this in perspective, one acre of temperate forest sequesters between 2.45 and 7.35 tons of CO_2 per acre per year.)

This worksheet will investigate how individual dietary choices can affect – and change – our national food-related carbon footprint.





Photos left to right: irrigation system (USDA, 2012), cattle hauling truck (RyanP77, 2013), meat counter at a grocery store (Murtaugh, 2004), refrigerated section of grocery store (Allen, 2005), and a hamburger (Talbert, 2008).

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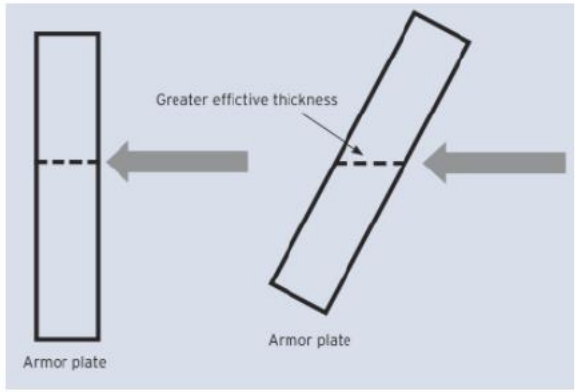
Sample 113 Task



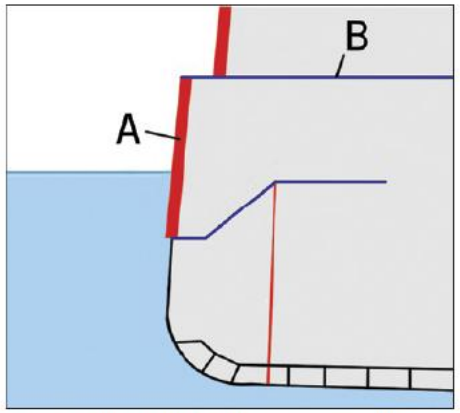


Fig. 2 Belt armor is indicated by A; deck armor, by B

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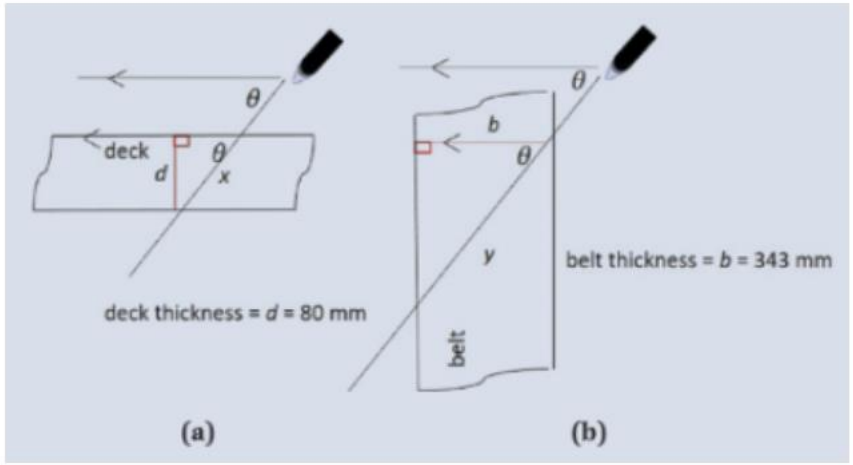

the belt and horizontally on the deck as in Figure 3.

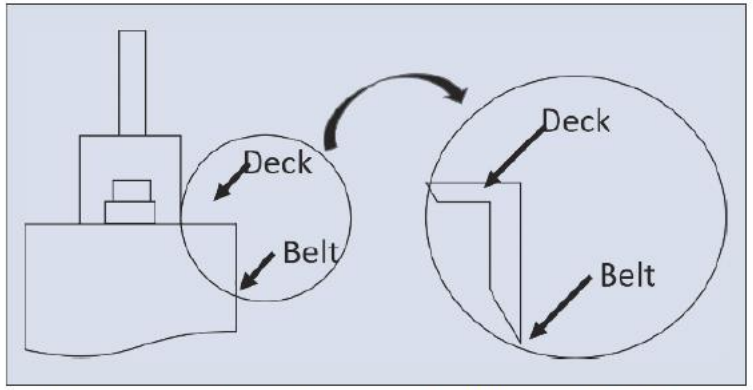

Fig. 3 This sketch shows the location of the deck and belt armor of a battleship.

Questions?

THANKS!!!

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