Research on teaching and how it relates to graduate student professional development

Spoiler: Knowledge of Student Thinking is Key

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Q: What formula defines the area, *A*, of a square, in terms of its perimeter, *p*?

a. $A = \left(\frac{p}{4}\right)^2 = \frac{p^2}{16}$ (correct)

b. $A = s^2$

c. $A = \frac{p^2}{4}$

d. $A = 16x^2$

e. $p = 4\sqrt{A}$

(Carlson, Oehrtman & Engelke, 2010)

Distractors?
What thinking would they reflect?

Q: What formula defines the area, *A*, of a square, in terms of its perimeter, *p*?

a. $A = \left(\frac{p}{4}\right)^2 = \frac{p^2}{16}$ (correct) 25%

b. $A = s^2$ 34%

c. $A = \frac{p^2}{4}$ 20%

d. $A = 16x^2$ 18%

e. $p = 4\sqrt{A}$ 3%

Most frequent?
Least frequent?

(Carlson, Oehrtman & Engelke, 2010)

Discuss with those around you

- How did you generate the distractors?
- How did you know which would be most common?
- How (when? where?) did you learn these things?

Outline

- Multiple choice distractors (done)
- Research into factors that shape teaching and learning
- TAs learning while teaching
- Ideas for applying research findings to graduate student professional development

Research on undergraduate mathematics education

- Ancient history (circa 1970s-1990)
  - studies of student performance
- More recent history (1990-2000)
  - studies of student performance
  - laboratory studies of student learning
- Very recent history (2000-present)
  - studies of students based in classrooms
  - studies of teacher characteristics, experiences, practices

Extremely rare (Speer, Smith & Horvath, 2010)

Related Research on K-12 teaching

- Teaching “mechanics”
  - blackboard use
  - clarity of speech
  - general organization
- These are necessary but far, far from sufficient to ensure high quality instruction and student learning

Content knowledge "The Math"

- Necessary, but also not sufficient (Ball & Bass, 2000; Hill, Rowan, & Ball, 2005; Hill, Sleep, Lewis, & Ball, D., 2007; Monk, 1994)
- More courses in content are not strongly correlated with higher student achievement (Begle, 1979; Monk, 1994)

"The conclusions of the few studies in this area are especially provocative because they undermine the certainty often expressed about the strong link between college study of a subject matter and teacher quality"

(Wilson, Floden, & Ferrini-Mundy, 2002, p. 191)

What else matters?

- Knowledge of student solution strategies (Fennema et al., 1996; Fennema, Franke, & Carpenter, 1993)
- Pedagogical Content Knowledge (Shulman, 1986; Grossman, Wilson & Shulman, 1989)
- Other knowledge used to do the work of teaching mathematics (Ball, Hoover Thames, & Phelps, 2008; Hill, Rowan, & Ball, 2005; Hill, Schilling, & Ball, 2004; Hill, Sleep, Lewis, & Ball, 2007; McCrory, Floden, Ferrini-Mundy, Reckase, & Senk, 2012)

Main point of this talk:

Knowing how students think (correctly and incorrectly) about particular mathematical ideas is key to a teacher providing high quality opportunities for students to learn.

Knowledge of Student Thinking is Key

Knowledge of Student Thinking is Key

Rest of talk:

- Convince you that this is true
- Explore implications of this for professional development at the college level

Example research findings

Teachers who can identify distractors have students who learn more. *

- Middle school physical science
- Multiple choice test
- 9,556 students
- 181 teachers: answer questions and predict which wrong answer will be selected most often
- connect teacher responses to student performance (gains)

*Sadler, P. M., Sonnert, G., Coyle, H. P., Cook-Smith, N., & Miller, J. L. (2013). The Influence of Teachers' Knowledge on Student Learning in Middle School Physical Science Classrooms. *American Educational Research Journal*.

Items with no single popular wrong answer (no strong distractor)

- teachers' abilities to identify the correct answer was positively correlated with student gains

Items with a strong distractor

- teachers who gave the correct answer for the item had larger gains than others
- teachers who could identify the strong distractor had **even larger** student gains

Content knowledge – good

Knowledge of student thinking – better

Research on Knowledge of Student Thinking

Examples:

- Cognitively Guided Instruction (e.g., Fennema et al., 1996; Fennema, Franke, & Carpenter, 1993)
- Mathematical Knowledge for Teaching (e.g., Hill, Rowan, & Ball, 2005; Hill, Schilling, & Ball, 2004)
- Knowledge for Algebra Teaching (McCrory et. al., 2012)

What does this mean for college math TAs?

Graduate students as teachers:

- They possess: Substantial (and expanding) knowledge of mathematics
- They typically lack: Experience and preparation for teaching
- Departments typically provide: Training in the mechanics of teaching

Unfortunately…

- Not always possible to provide substantial pre-service preparation
- Not always feasible to provide extensive professional development concurrent with early teaching experiences
- TA professional development is not a primary focus for faculty

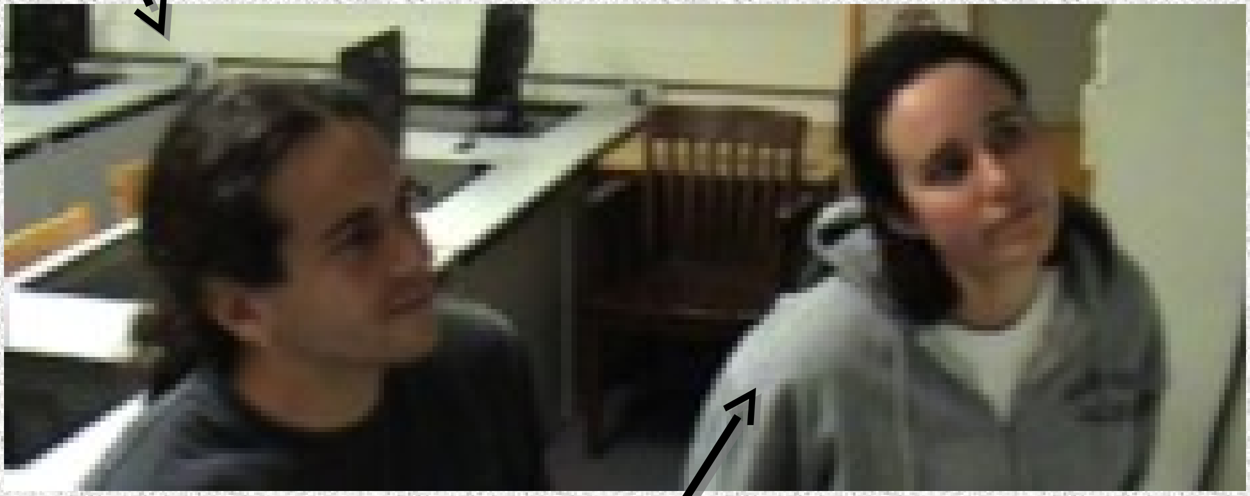
TA learning occurs on-the-job

Teach graduate students to learn about student thinking from their teaching experiences.

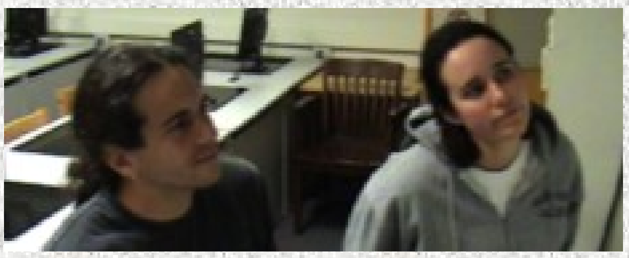
Video activity

$$1, 0, \frac{1}{2}, 0, \frac{1}{3}, 0, \frac{1}{4}, 0 \ldots$$

Sandy: “The terms aren’t, like, going to zero.”



Cindy: “No, they are, they both are.”



$$1, 0, \frac{1}{2}, 0, \frac{1}{3}, 0, \frac{1}{4}, 0 \ldots$$

Sandy: “The terms aren’t, like, going to zero.”

Cindy: “They are, they both are.”

- What does each student mean?
- What knowledge are you drawing on to answer this question?
- Where did you gain that knowledge?
- How can we structure experiences for TAs so they (more quickly) gain this type of knowledge?

TAs Learning on the Job

How can we structure experiences for TAs so they (more quickly) gain this type of knowledge?

- We know some about how TAs learn these things (Kung, 2010)
- “On the job learning” research at K-12 level (Sherin, 2002; Little & Horn, 2007)
- Experiential Learning (Kolb, 1984)

Where could TAs use/gain knowledge of student thinking?

Framework for thinking about:

- what TAs have opportunities to do
- how they might gain & use knowledge of student thinking
- what PD to support this might look like

Reverse-Engineering

Framework of knowledge use, acquisition, and development

Practice ↓	Using knowledge	Gaining knowledge	PD to support learning
Planning			
Instructing			
Assessing			
Reflecting			

Framework of knowledge use, acquisition, and development

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Using knowledge: Short term planning

Practice ↓	Using knowledge
Planning	Choosing/constructing examples Selecting content to include (and/or emphasize) Selecting instructional activities (groupwork, lecture presentation, etc.) Sequencing content/examples

Framework of knowledge use, acquisition, and development

Practice ↓	Using knowledge	Gaining knowledge	PD to support learning
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Reflecting			

Gaining knowledge: Instructing

Practice ↓	Gaining knowledge
Instructing	Noticing patterns in students' questions Asking questions that elicit students' (correct and incorrect) reasoning Observing students as they work on and talk about problems

Framework of knowledge use, acquisition, and development

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Instructing			
Assessing			
Reflecting			

PD to support learning: Assessing

Practice ↓	PD to support learning
Assessing	Analyzing student work Quiz questions: write, predict, analyze Develop grading rubrics Interview students about written responses

Framework of knowledge use, acquisition, and development

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What is the goal of PD built on this framework?

Help TAs learn how to learn from their teaching experiences

- Develop appreciation for knowing about how student think about mathematical ideas
- Develop skills to inquire into how students think
- Develop strategies for using that knowledge in all parts of the teaching cycle

What could PD programs built on these principles include?

- Predicting and analyzing student thinking
- Clinical interviews
- Lesson Study
- Video Clubs
- Read research (*Making the Connection: Research to Practice in Undergraduate Mathematics Education*)
- Video Case Studies
- (Eventually) our book *What Could They Possibly Be Thinking? Understanding your college math students.*

Philosophical Perspective

"You learn mathematics by *doing* mathematics."

"You learn how to teach by *doing* teaching."

Views of TA professional development (PD):

- Traditional view: How to teach (mechanics).
- Our view: How to ***learn*** from your teaching.

Pay off of all this work?

- Teachers who create improved opportunities for students to learn
- "Generative" teaching practices (Franke et al, 2001)
- Improved student learning

- For more: *Mathematics teaching assistants learning to teach*

  (Kung & Speer, 2009)

- Acknowledgements
  - Department of Education (FIPSE grant # P116B060180)
  - Unpaid actors (St. Mary's College professors Katherine Socha, Sandy Ganzell, Cindy Traub)

- Contact information:
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EXTRA SLIDES