

Measuring Teacher Quality in Practice

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Learning Mathematics for Teaching Project

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Measurement Challenges and the Assessment of Teacher Quality

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University of Michigan
School of Education

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What signal strength on "teacher quality" do we need for what purposes, and what is involved in trying to measure it at that grain size?

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Overview

1. What is "teacher quality"?
2. Relating content knowledge and teacher quality: The case of mathematics
3. The use of content knowledge and teacher quality
4. From "teacher quality" to "teaching quality": Measuring the mathematical quality of instruction

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1. What is "teacher quality"?

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Teacher quality

- Many different conceptions and foci:
  - Holds a degree in the subject, is certified
  - Knows the subject
  - Is culturally responsive
  - Is pedagogically skillful
  - Produces gains in achievement
  - . . .
- Important for different purposes (decisions, theory, research)
- Policy wish: to identify "good" teachers
- Teacher education wish: to identify the characteristics of good teachers and how to help people acquire those characteristics; how to assess them

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1. What is "teacher quality"?

(a) Trying to measure teacher quality: The case of mathematics

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Commonly-used measures of mathematics teacher quality: What do they tell us?

1. Certification
2. Mathematics study (degrees, coursework)
3. Direct measures (tests)

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Teacher certification as a measure of teacher quality

Results

- Effect remains somewhat ambiguous
- Some studies show a positive effect of teachers' certification; others show no effect
- Imprecision of certification as a measure of quality

Issues

- An inexact measure of what teachers actually know
- May have problems of selection bias
- Different kinds of "certification" difficult to sort out in the studies

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Teacher course-taking as a measure of teacher quality

Results

- More consistent than certification studies
- Many do show a positive impact; but some show no impact, some show negative impact
- Most focus on secondary school students; no evidence for elementary
- Lacking detail about course content

Issues

- Not a direct measure of what teachers actually know
- Forgetting (time lapse)
- May not correspond to the math that teachers teach
- May have problems of selection bias

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Teachers' test scores as measures of teacher quality

Results

- Few studies that use tests of teachers' knowledge to relate teacher content knowledge to student achievement gains
- Support impact of teachers' mathematics knowledge on student achievement

Issues

- Closer estimates of what teachers actually know
- May lack validation
- Few studies

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Content knowledge as an indicator of teacher quality: What's the signal strength?

- Knowing mathematics is likely a significant factor in teaching math effectively
- College-level study may predict effectiveness for secondary school, not clear for elementary
- Imprecise discriminator of teacher quality

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What do we not know yet about content knowledge as an indicator of teacher quality?

- Detail about what teachers need to know
- How much coursework makes a difference at different levels of schooling
- How teachers' knowledge of mathematics affects the quality of students' learning

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Teachers do matter a lot

1. Persistent evidence that a large proportion of the variability in student achievement gains is due to who the teacher is
2. Less clear from the evidence exactly what it is about particular teachers that makes them more effective
3. Need to know how more effective teachers differ from less effective ones and how to measure this

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2. Relating content knowledge more closely to teacher quality

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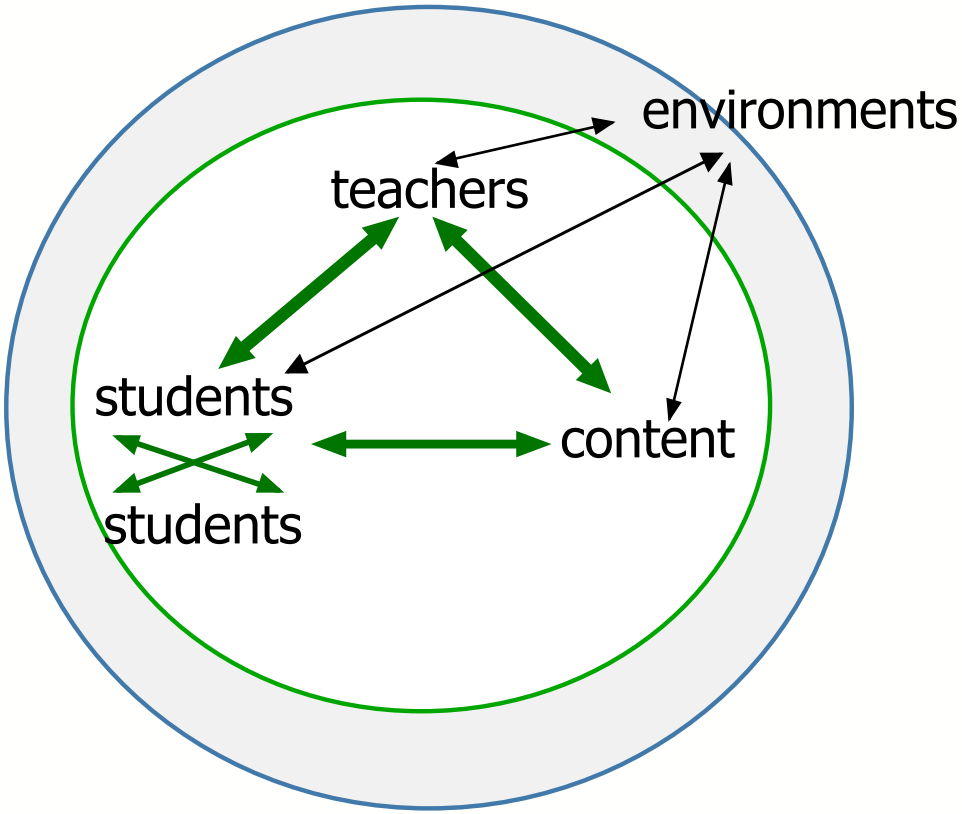
What is the "problem"?

The quality of mathematics teaching and learning

Teachers' knowledge of mathematics and their ability to use it in practice

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How does teacher quality affect students' opportunity to learn and learning?



- Teacher quality is a key resource for student learning
- Instruction as the "black box" of interactions among students, teachers, content
- Instruction takes place in environments
- Resources matter as they affect instruction

Cohen, Raudenbush, & Ball (2003). Resources, instruction, and research. EEPA.

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Toward a practice-based theory of mathematical knowledge for teaching (MKT)

1. Study instruction, and identify the mathematical work of teaching
2. Analyze what mathematical knowledge is needed to do that work effectively, and how it must be understood to be useful for the work
3. Develop, test, and refine measures of MKT using multiple methods as a means to evaluate professional education, investigate effects on students' learning, and improve theory

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Mathematical knowledge for teaching (MKT)

- What do we mean when we use this term, "mathematical knowledge for teaching"?
  - Mathematical knowledge, skill, habits of mind that are entailed by the work of teaching

- What do we mean by the "work of teaching"?
  - The tasks in which teachers engage, and the responsibilities they have, to teach mathematics, both inside and outside of the classroom

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Knowing multiplication

$$\begin{array}{r} 49 \\ \times\ 25 \end{array}$$

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Knowing multiplication for teaching

How did students get each of these answers?

(a)

$$\begin{array}{r} 49 \\ \times\ 25 \\ \hline 405 \\ 108 \\ \hline 1485 \end{array}$$

(b)

$$\begin{array}{r} 49 \\ \times\ 25 \\ \hline 225 \\ 100 \\ \hline 325 \end{array}$$

(c)

$$\begin{array}{r} 49 \\ \times\ 25 \\ \hline 1250 \\ 25 \\ \hline 1275 \end{array}$$

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Knowing radical expressions

Simplify: $\sqrt{150}$

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Knowing radical expressions for teaching

Which of the following is best for setting up a discussion about different solution paths for simplifying radical expressions?

(a) $\sqrt{54}$

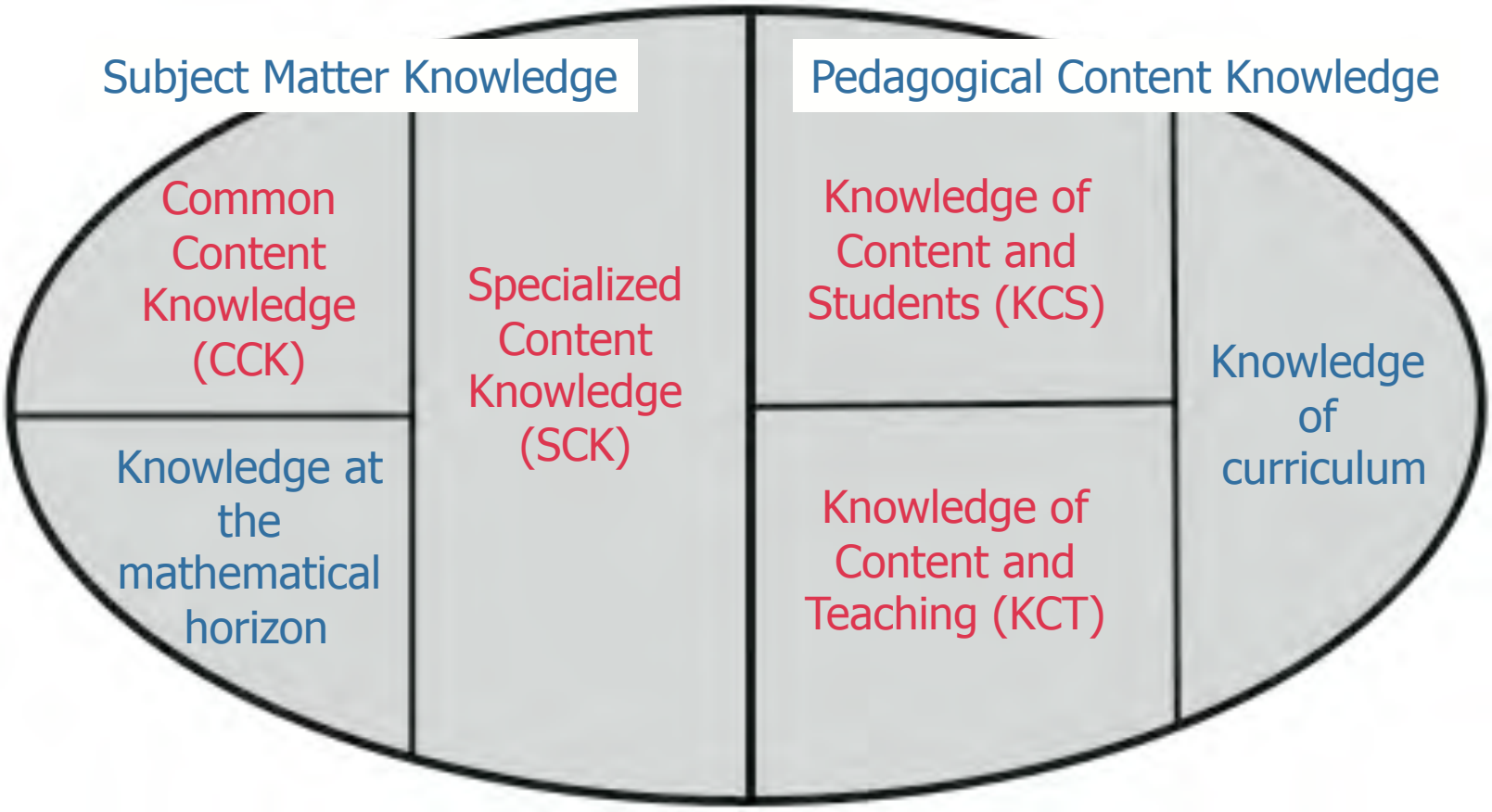
(b) $\sqrt{156}$

(c) $\sqrt{128}$

(d) These examples all work equally well.

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Mathematical knowledge for teaching



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3. Measuring the use of content knowledge as teacher quality

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Using MKT to develop measures of teacher knowledge

- Focused on the use of mathematical knowledge in teaching:
  - Started with number concepts, operations, algebra (K-5); later through 8, geometry, probability, proportional reasoning
  - Focused on recurrent tasks of teaching where content knowledge is used (e.g., analyzing = solutions, choosing examples, representing content, explaining, evaluating student work
- Can be used at scale
- Many stages of work to develop items

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Sample item A:
Choosing examples: Ordering decimals

Which of the following lists would be best for assessing whether your students understand decimal ordering?

A.	.5	7	.01	11.4
C.	.60	2.53	3.12	.45
D.	.6	4.25	.565	2.5

E. These lists are all equally good for assessing whether students understand how to order decimal numbers.

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Sample item B:
Evaluating unconventional solutions: Multiplication

Which student is using a method that could be used to multiply any two whole numbers?

Student A	Student B	Student C
35 x25 125 +75 875	35 x25 175 +700 875	35 x25 25 150 100 +600 875

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Validating measures of MKT

1. Teachers' scores reflect their mathematical thinking
   - Cognitive interviews
2. Scores reflect common and specialized knowledge of content
   - Mathematician and non-teacher interviews
3. Higher scores related to improved student learning
   - Student gains analysis
4. Higher scores mean higher-quality mathematics instruction
   - Videotape validation study

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Linking teacher knowledge and student achievement

- Questionnaire consisting of 30 items (scale reliability .88)
- Model: Student Terra Nova gains predicted by:
  - Student descriptors (family SES, absence rate)
  - Teacher characteristics (math methods/content, content knowledge)
- Teacher content knowledge significant
  - Small effect (< 1/10 standard deviation): 2-3 weeks of instruction
  - But student SES is also about the same size effect on achievement

(Hill,Rowan, and Ball, AERJ, 2005)

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4. From "teacher quality" to "teaching quality": Measuring qualities of instruction

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Efforts to measure qualities of instruction

- Borko, Stecher, et al. : "scoops" of teachers' work to measure whether practice is "reform-oriented"
- Horizon surveys of teacher practice: combining reform practices, routines, beliefs
- PACT: assessment of clusters of work called "teaching events"
- National Board of Professional Teaching Standards

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Two efforts to get inside instruction

- Teacher log to capture daily opportunities to learn in mathematics and ELA (The Study of Instructional Improvement)
- Videocodes for the mathematical quality of instruction (Learning Mathematics for Teaching Project)
- Both are about instructional actions
- Neither is about "reform"
  - The log is agnostic
  - The videocodes place a big bet on the role of content

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Mathematical quality of instruction (MQI)

- What do we mean when we use this term, "mathematical quality of instruction"?
  - A composite of elements that shape the richness, rigor, and effectiveness of the mathematical content and its use with students, including:
    - Language use – including everyday vs. mathematical language
    - Representation of mathematical ideas
    - Linkages between classroom task (i.e., what kids are doing) and important mathematical ideas
    - Facility in listening to and using children's mathematical productions
    - Computational or other mathematical errors
    - Use of mathematics to teach equitably

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Investigating the "mathematical quality of instruction" (MQI)

- What is the overall strength of the relationship between teachers' mathematical knowledge for teaching and the mathematical quality of their instruction?
- What does MKT afford instruction? How does a lack of MKT constrain instruction?
- What factors mediate the expression of MKT in instruction?
- In which tasks of teaching is MKT – whether strong or weak – most apparent?

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Sample coding of MQI: Using representations in teaching

Grade 4 class; experienced teacher

Code for:

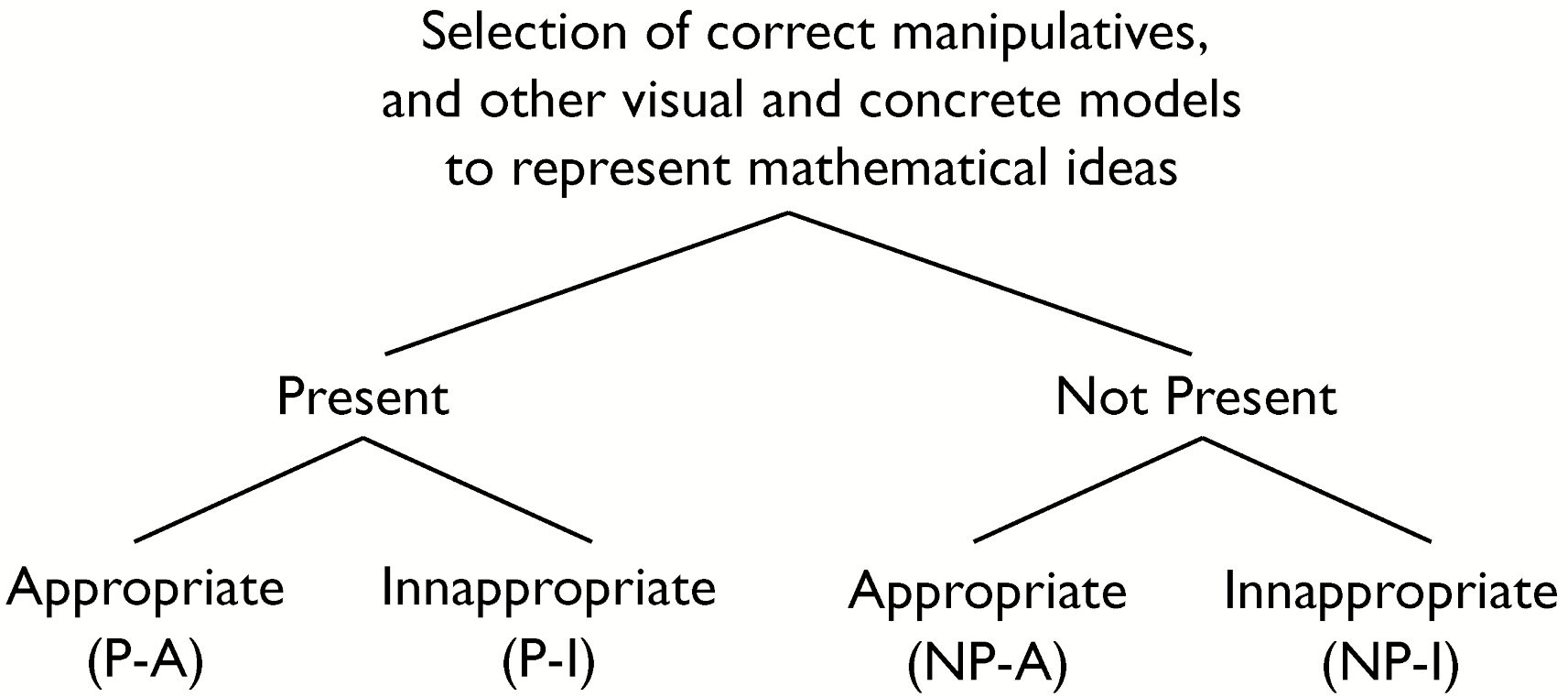
a) Selection of appropriate manipulatives, and other visual and concrete models to represent mathematical ideas

b) Multiple models: Whether or not the teacher uses more than one model for the mathematical content.

e) Makes explicit links among any combination of symbols, concrete pictures, diagrams, etc.

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Assessing performance



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Recording codes

e. Selection of manipulatives, and other visual and concrete models to represent mathematical ideas			
Present		Not Present	
Appropriate	Inappropriate	Appropriate	Inappropriate

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Daily warm-ups: Practice with positive and negative mixed numbers

1. $-4\frac{2}{3}+1\frac{5}{6}$

2. $1\frac{3}{8}-\frac{-3}{4}$

3. $-1\frac{2}{5}\cdot-3\frac{1}{2}$

4. $2\frac{1}{8}\div1\frac{3}{4}$

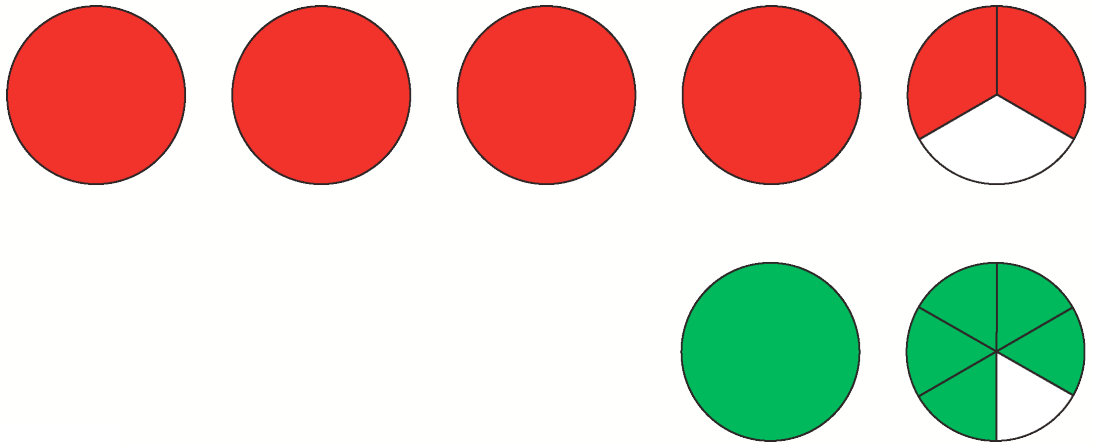
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Modeling addition of negative and positive fractions

$$-4\frac{2}{3}+1\frac{5}{6}$$

- Red "pies" to represent negative numbers
- Green "pies" to represent positive numbers



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Assessing performance on elements

To code, first decide whether the element is present (P) or not present (NP). If present, then:

- Mark appropriate (A) if the teacher's use of the element was, for the most part, mathematically accurate and appropriate—it did not distort the mathematics.
- Mark inappropriate (I) if the teacher's use of the element distorted the mathematics or was inappropriate for the grade level.

If not present, then:

- Mark appropriate (A) if absence of the element seems appropriate.
- Mark inappropriate (I) if absence of the element seems problematic—i.e., the element should have happened.

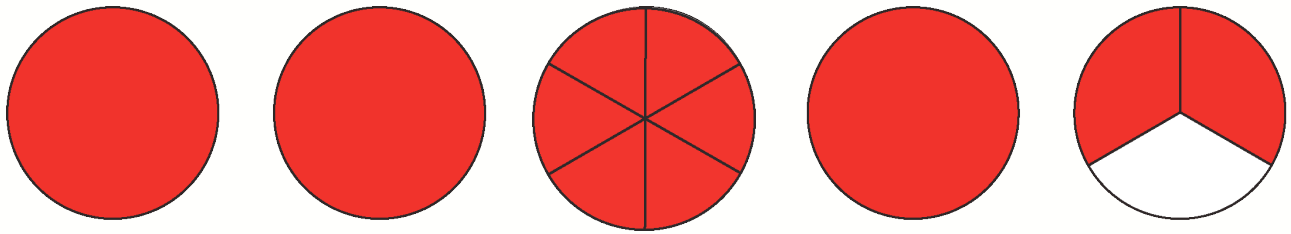
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Videoclip

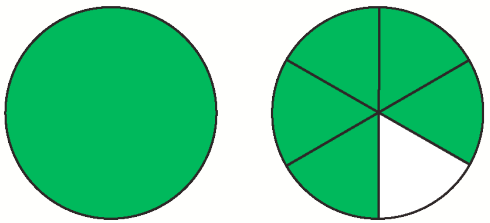
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Modeling $-4\frac{2}{3} + 1\frac{5}{6}$

- Red "pies" to represent negative numbers
- Green "pies" to represent positive numbers



Answer: $-2\frac{5}{6}$



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Linking teacher knowledge and the mathematical quality of instruction

- Coding the mathematical quality of instruction (MQI)
  - Video of 10 teachers (9 lessons each, pre & post interviews, curriculum materials)
  - 33 codes (reliability ≈ .85) & 6 meta-codes (reliability ≈ .54 to .91)
  - Blind to teachers' MKT scores
- Model:
  - teacher MKT ⟹ mathematical quality of instruction
- Teacher MKT significant
  - Spearman correlations from .41 to .83
  - Low knowledge correlated with low mathematical quality of instruction (errors, language, responding to students)

http://sitemaker.umich.edu/lmt/home

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What have we learned?

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Challenges of measuring teacher quality in practice

- What of practice to measure
- Underconceptualization of practice, and accompanying lack of language
- How to get to the technical core, and not get stuck in superficial features
- Adequate sampling of practice
- Getting clear: evaluation versus description versus careful analysis
- Lack of developmental markers for practice
- Lack of precision about the interaction of instruction and context

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