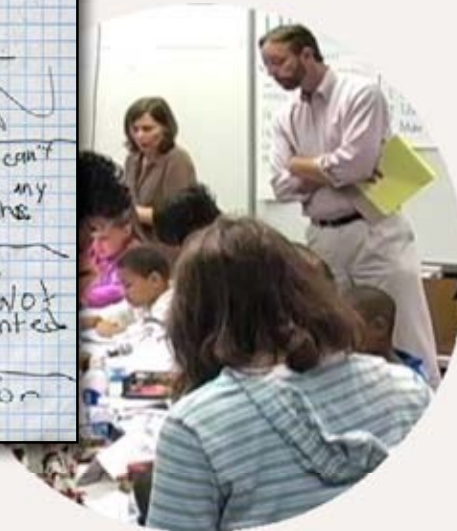


Expertise in Teaching Practice

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Designing a K-5 Mathematics Specialist Program
May 17, 2009

Overview

1. “Mathematics specialists”: What are we talking about? And the problems we face
2. Expertise in mathematics
3. Developing and refining expertise in mathematical teaching practice

1. What are we talking about?

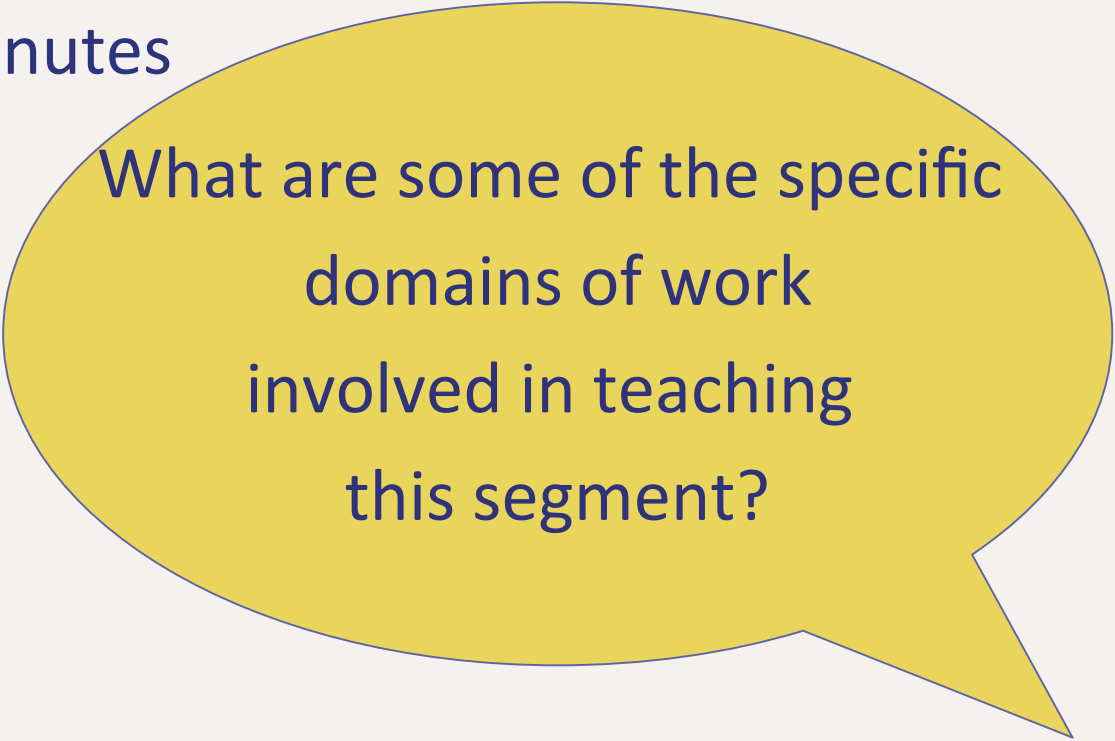
What is a an elementary mathematics specialist teacher?

- Exact roles may vary substantially, but this is:
- A teacher with expertise in the teaching of elementary mathematics
 - teaching
 - elementary (students and environments)
 - mathematics

What is there is to be expert *in*?

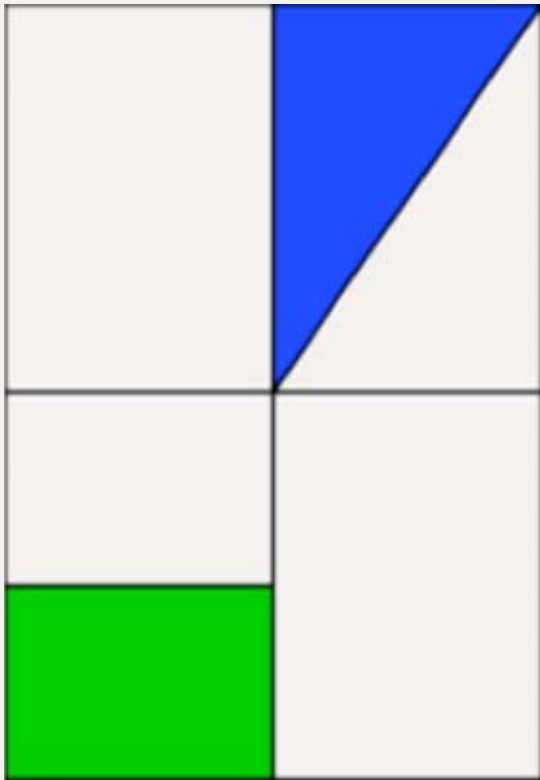
One look

1. “Off camera”: Before this episode
2. During these 6 minutes



What are some of the specific domains of work involved in teaching this segment?

Mathematical task, grade 4-5



- What fraction of the big rectangle is shaded blue?
- What fraction of the big rectangle is shaded green?
- What fraction of the big rectangle is shaded altogether?

Video clip

- Discussion of warm up problem
- Focused attention on equal parts
- Developing working ideas about fractions
 1. Identify the whole
 2. Make equal parts
 3. Count how many equal parts out of the whole

Viewing focus

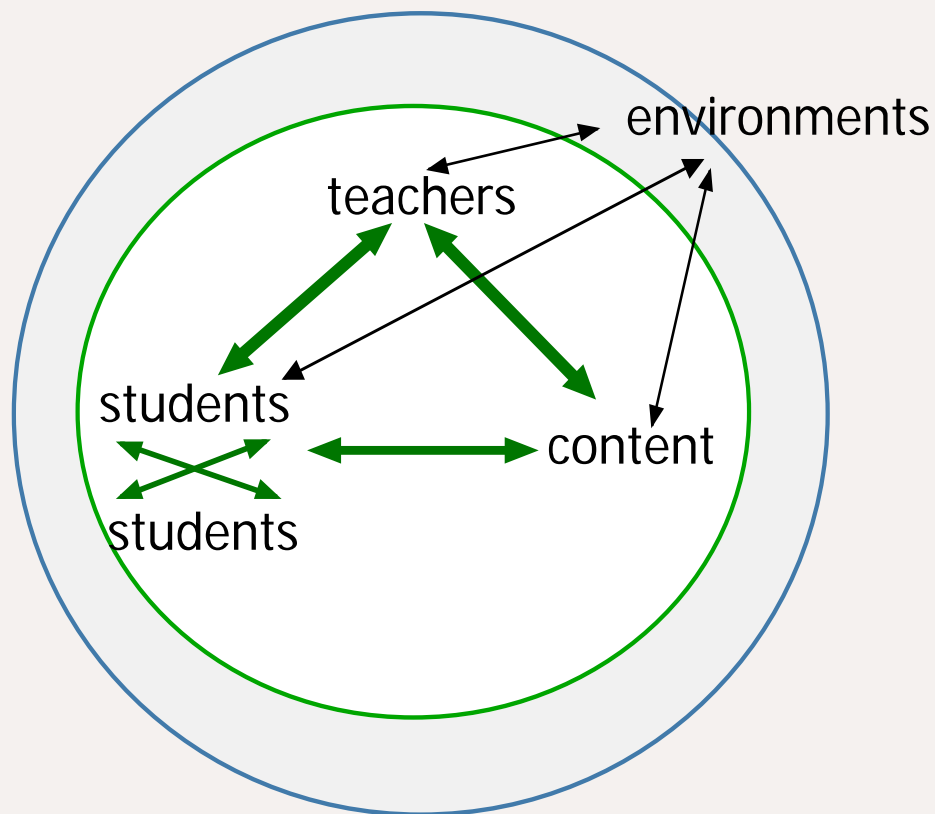
- What is the work of teaching in this clip?
- What mathematical “knowledge” is entailed by that work?



Examples of work of teaching

1. Selecting/designing tasks
2. Identifying and working toward the mathematical goal of the lesson
3. Listening to and interpreting students' responses
4. Teaching students what counts as “mathematics” and mathematical practice
5. Making error a fruitful site for mathematical work
6. Attending to ambiguity of “big rectangle”
7. Deciding what to clarify, what to make more precise, what to leave in student's own language

What is the terrain of “teaching elementary mathematics”?



- Instruction as the “black box” of interactions among students, teachers, content
- Practicing teachers seek to connect their teaching to students’ learning.
- Coordinating, over time, and with groups of students to accomplish specific goals

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

So we want to prepare elementary mathematics specialists?

What problems do we face?

Apparent problems

- Structure
- Recruitment incentives
- Curricular design
- Instructors
- Assessments

Big problem #1: In search of mathematical expertise in teaching

- What mathematicians know
- Mathematics beyond K-5 level (policy documents)
- Profound understanding of fundamental mathematics (Ma)
- Elementary mathematics from an advanced standpoint (Klein)
- Students' mathematical thinking (CGI, Friel, Phillips, many others)
- Pedagogical content knowledge (Shulman)

Big problem #2:

Teaching is underspecified in our culture

- Learning is romanticized
- Limited and misleading language (classroom processes, development, facilitation, no word for the fundamental transaction)
- Lack of frameworks for seeing teaching
- Grain size issues: at what scale to look
- Disciplinary traditions and perspectives that focus closely only on part of the story
- Expertise and tacit knowledge

Our challenge

- How to develop and extend expertise in practice, specifically:
 - Mathematical knowing in and for teaching
 - Teaching practice

2. Knowing mathematics for teaching

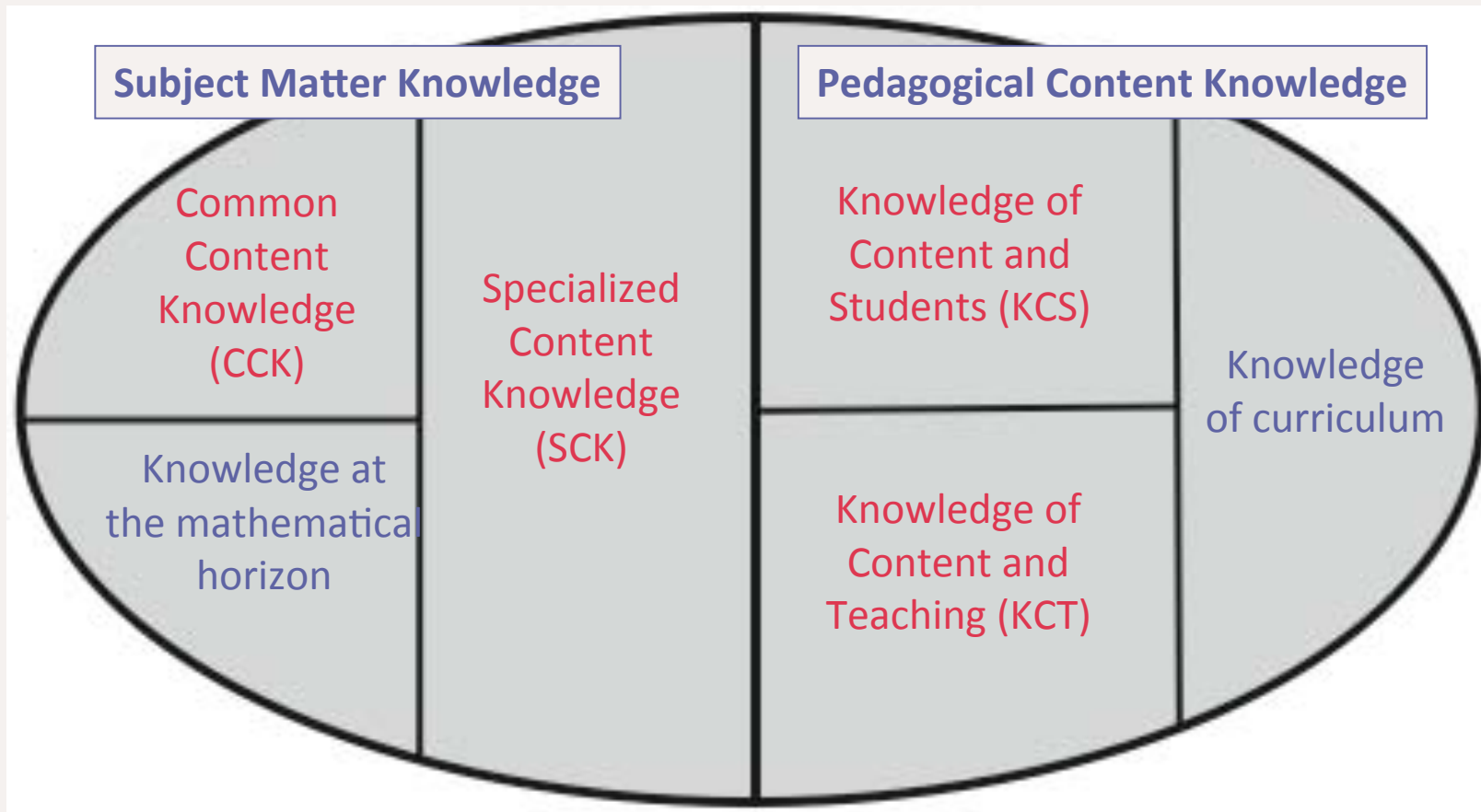
Elements of our “practice-based” approach

1. Study instruction and identify the mathematical work of teaching
2. Analyze what mathematical knowledge is entailed by the work (MKT)
3. Test the working hypotheses based on these analyses by developing measures of MKT, validating teacher scores against practice and against student achievement gains
4. Develop and evaluate approaches to helping teachers learn mathematical knowledge for teaching

Mathematical knowledge for teaching (MKT)

- Frame: knowledge used in practice
 - “knowledge *entailed* by the work of teaching”
- What do we mean by “knowledge”?
 - Mathematical knowledge, skill, habits of mind
- What do we mean by the “work of teaching”?
 - The activities in which teachers engage, and the responsibilities they have, to teach mathematics, both inside and outside of the classroom

Mathematical knowledge for teaching



Common content knowledge (CCK)

Calculate:

$$\frac{5}{6} \div \frac{1}{3}$$

Specialized content knowledge (SCK)

$$\frac{5}{6} \div \frac{1}{3} = \frac{10}{12} \div \frac{4}{12} = 10 \div 4 = 2\frac{1}{2}$$

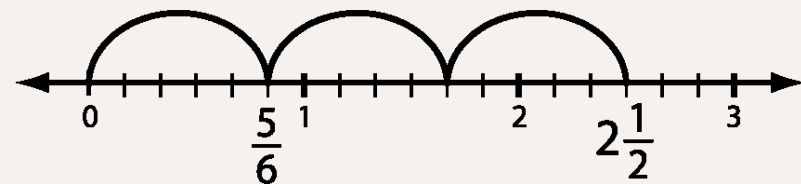
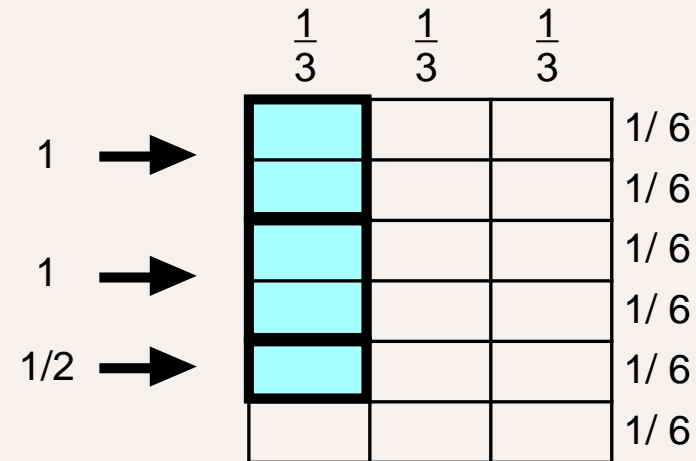
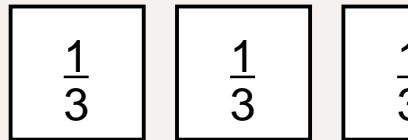
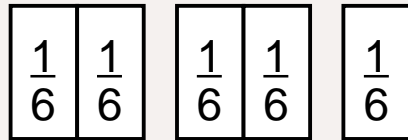
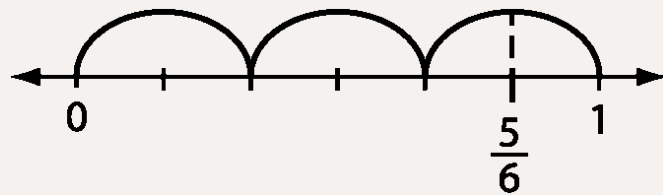
Is this a fluke?

Does it work in general?

If so, why does it work?

Specialized content knowledge (SCK)

Which of these can be used to represent $\frac{5}{6} \div \frac{1}{3}$?



$$\frac{5}{6} \div \frac{1}{3} = 2\frac{1}{2}$$

Knowledge of students and content (KCS)

- What are common errors students make when dividing fractions?
- How do students' experiences with division of whole numbers support their understanding of division of fractions? How does it confuse them?
- What difficulties do students typically have interpreting the answer to a division of fractions problem?

Knowledge of teaching and content (KCT)

- Which representation would you use to introduce the meaning of division of fractions? Or to explain the invert and multiply algorithm?
- What sequence of problems would you use to begin work on division of fractions?
- In a whole-class discussion, what solution methods would you want presented, and in what order?

Other tasks of teaching mathematics

- Responding to students' "why" questions
- Unpacking and decomposing mathematical ideas
- Explaining and guiding explanation
- Using mathematical language and notation
- Generating examples
- Sequencing ideas
- Choosing and using representations
- Analyzing errors
- Interpreting and evaluating alternative solutions and thinking
- Analyzing mathematical treatments in textbooks
- Making mathematical practices explicit
- Attending to issues of equity (e.g., language, contexts, mathematical practices)

3. Developing and refining expertise in mathematics teaching practice

Core practices of teaching

- Useful: Frequently needed
- Big payoff: Highly effective for helping students learn
- Must be learned (and taught): Not intuitive, even unnatural

Examples of high leverage core practices

- Diagnosing students' difficulties
- Using the board clearly
- Using a discussion to help students participate in and learn mathematics
- Choosing mathematical examples
- Using representations
- Communicating with parents about students' progress and needs

The practice of being an elementary mathematics specialist teacher . . .

Entails expertise in **mathematics, teaching**, and the learners and contexts of **elementary** school.

Examples of the work:

- Teaching multiple grade levels on a given day
- Co-planning lessons
- Leading professional development for colleagues
- Teaching demonstration lessons
- Designing learning opportunities for teachers

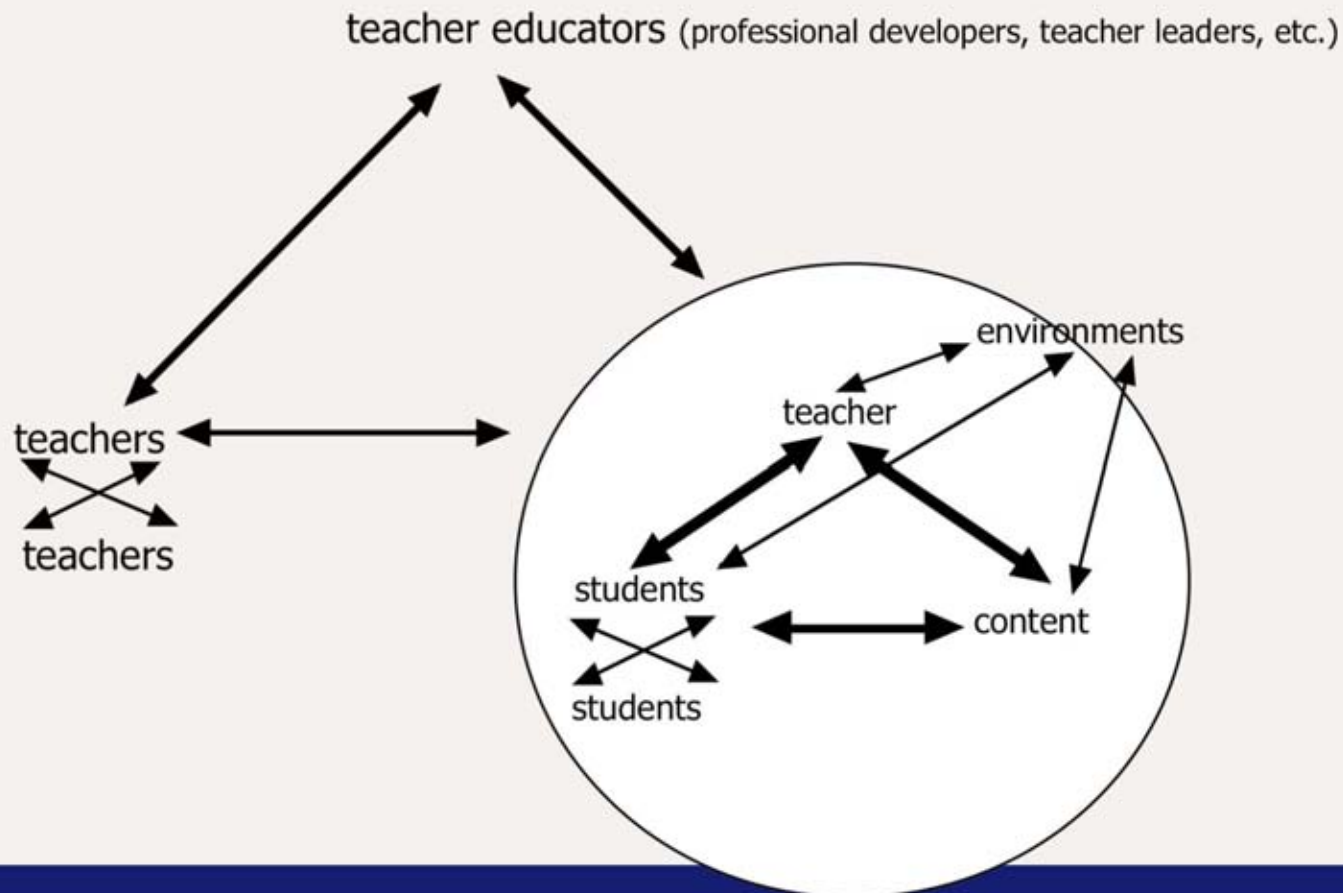
Aspects of developing elementary mathematics specialists

Aspect 1: Help interested teachers develop greater depth of knowledge and practice

Aspect 2: Help accomplished teachers learn to have the perspective on their own practice and greater breadth, explicitness, and context for the teaching of elementary mathematics

Aspect 3: Help accomplished teachers develop the knowledge, skills, and dispositions needed to help other teachers learn

Teaching practice as the content of professional expertise



Creating opportunities to learn —

1. The practice of mathematics in and for teaching
2. Teaching practice itself (including experience with settings and learners beyond own)
3. Explicitness and breadth about both (including ability to be fluent in narrating MKT and practice, and a stronger sense of the broader context)
4. Practices of and knowledge entailed by the work of teacher development (e.g., knowledge of teachers as learners, ways to help other teachers learn, identity as a teacher leader, ability to talk across communities and stakeholders)

Challenges of centering program on teaching and mathematical practice

1. Fascination with mathematics itself
2. Fascination with children's thinking
3. Problem of expertise and tacit knowledge
4. Widely held view of teaching as uncertain, artistic, and unable to be specified
5. Underdeveloped pedagogy of practice

Resources for centering program on teaching and mathematical practice

1. Clinical education in other professions (Grossman)
2. The growing archive of different kinds of cases and artifacts
3. A community of practice for developing a pedagogy centered in and on practice

Thank you!

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