Expertise in Teaching Practice







Deborah Loewenberg Ball

University of Michigan

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

© 2009 Mathematics Teaching and Learning to Teach
School of Education • University of Michigan • Ann Arbor, MI 48109-1259 • (734) 615-7235 • mtlt@umich.edu

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

© 2009 Mathematics Teaching and Learning to Teach
School of Education • University of Michigan • Ann Arbor, MI 48109-1259 • (734) 615-7235 • mtlt@umich.edu

1. What are we talking about?

© 2009 Mathematics Teaching and Learning to Teach
School of Education • University of Michigan • Ann Arbor, MI 48109-1259 • (734) 615-7235 • mtlt@umich.edu

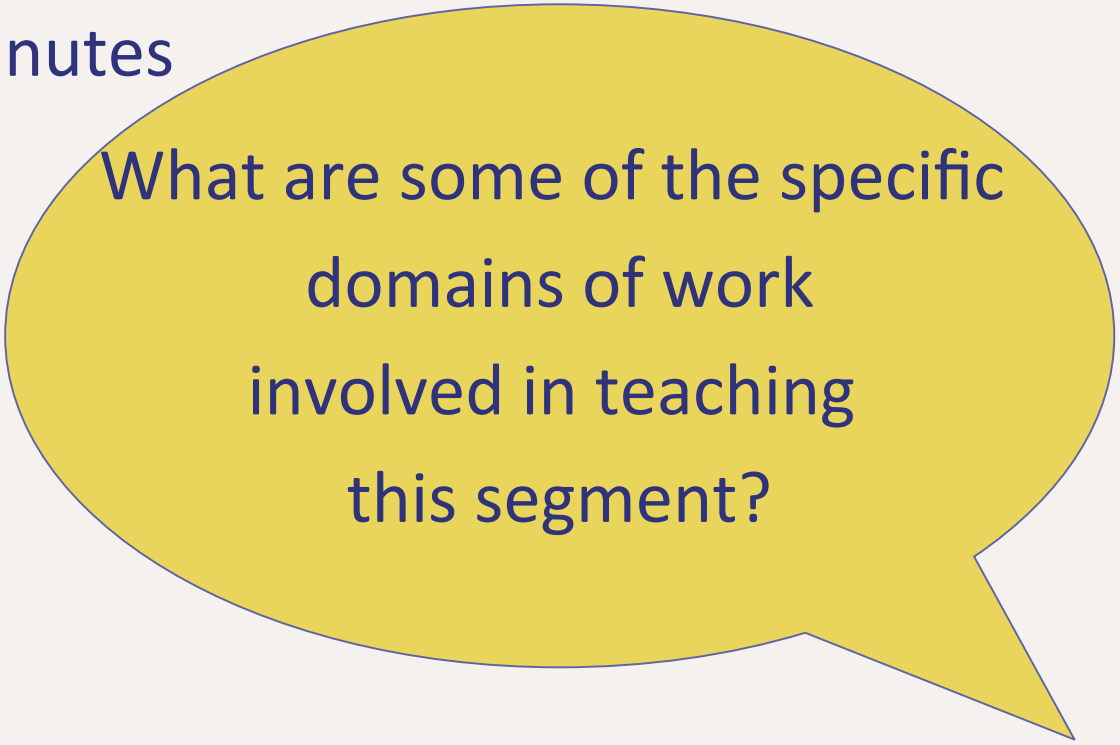
What is a an elementary mathematics specialist teacher?

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

© 2009 Mathematics Teaching and Learning to Teach
School of Education • University of Michigan • Ann Arbor, MI 48109-1259 • (734) 615-7235 • mtlt@umich.edu

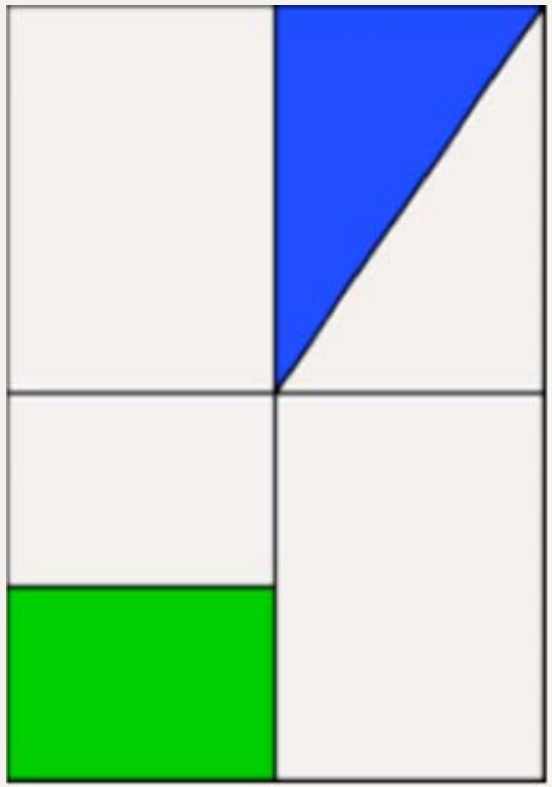
What is there is to be expert *in*? One look

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



© 2009 Mathematics Teaching and Learning to Teach
School of Education • University of Michigan • Ann Arbor, MI 48109-1259 • (734) 615-7235 • mtlt@umich.edu

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?

© 2009 Mathematics Teaching and Learning to Teach
School of Education • University of Michigan • Ann Arbor, MI 48109-1259 • (734) 615-7235 • mtlt@umich.edu

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

© 2009 Mathematics Teaching and Learning to Teach
School of Education • University of Michigan • Ann Arbor, MI 48109-1259 • (734) 615-7235 • mtlt@umich.edu

Viewing focus

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

© 2009 Mathematics Teaching and Learning to Teach
School of Education • University of Michigan • Ann Arbor, MI 48109-1259 • (734) 615-7235 • mtlt@umich.edu



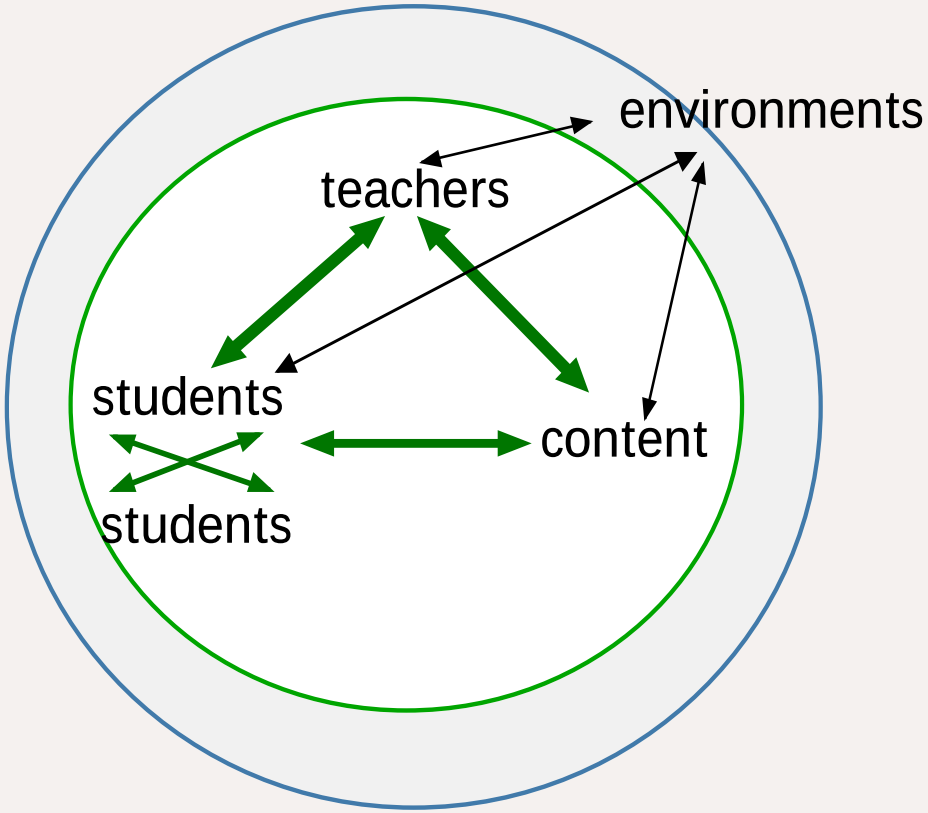
© 2009 Mathematics Teaching and Learning to Teach
School of Education • University of Michigan • Ann Arbor, MI 48109-1259 • (734) 615-7235 • mtlt@umich.edu

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

© 2009 Mathematics Teaching and Learning to Teach
School of Education • University of Michigan • Ann Arbor, MI 48109-1259 • (734) 615-7235 • mtlt@umich.edu

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.

© 2009 Mathematics Teaching and Learning to Teach
School of Education • University of Michigan • Ann Arbor, MI 48109-1259 • (734) 615-7235 • mtlt@umich.edu

So we want to prepare elementary mathematics specialists?

What problems do we face?

© 2009 Mathematics Teaching and Learning to Teach
School of Education • University of Michigan • Ann Arbor, MI 48109-1259 • (734) 615-7235 • mtlt@umich.edu

Apparent problems

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

© 2009 Mathematics Teaching and Learning to Teach
School of Education • University of Michigan • Ann Arbor, MI 48109-1259 • (734) 615-7235 • mtlt@umich.edu

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)

© 2009 Mathematics Teaching and Learning to Teach
School of Education • University of Michigan • Ann Arbor, MI 48109-1259 • (734) 615-7235 • mtlt@umich.edu

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

© 2009 Mathematics Teaching and Learning to Teach
School of Education • University of Michigan • Ann Arbor, MI 48109-1259 • (734) 615-7235 • mtlt@umich.edu

Our challenge

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

© 2009 Mathematics Teaching and Learning to Teach
School of Education • University of Michigan • Ann Arbor, MI 48109-1259 • (734) 615-7235 • mtlt@umich.edu

2. Knowing mathematics for teaching

© 2009 Mathematics Teaching and Learning to Teach
School of Education • University of Michigan • Ann Arbor, MI 48109-1259 • (734) 615-7235 • mtlt@umich.edu

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

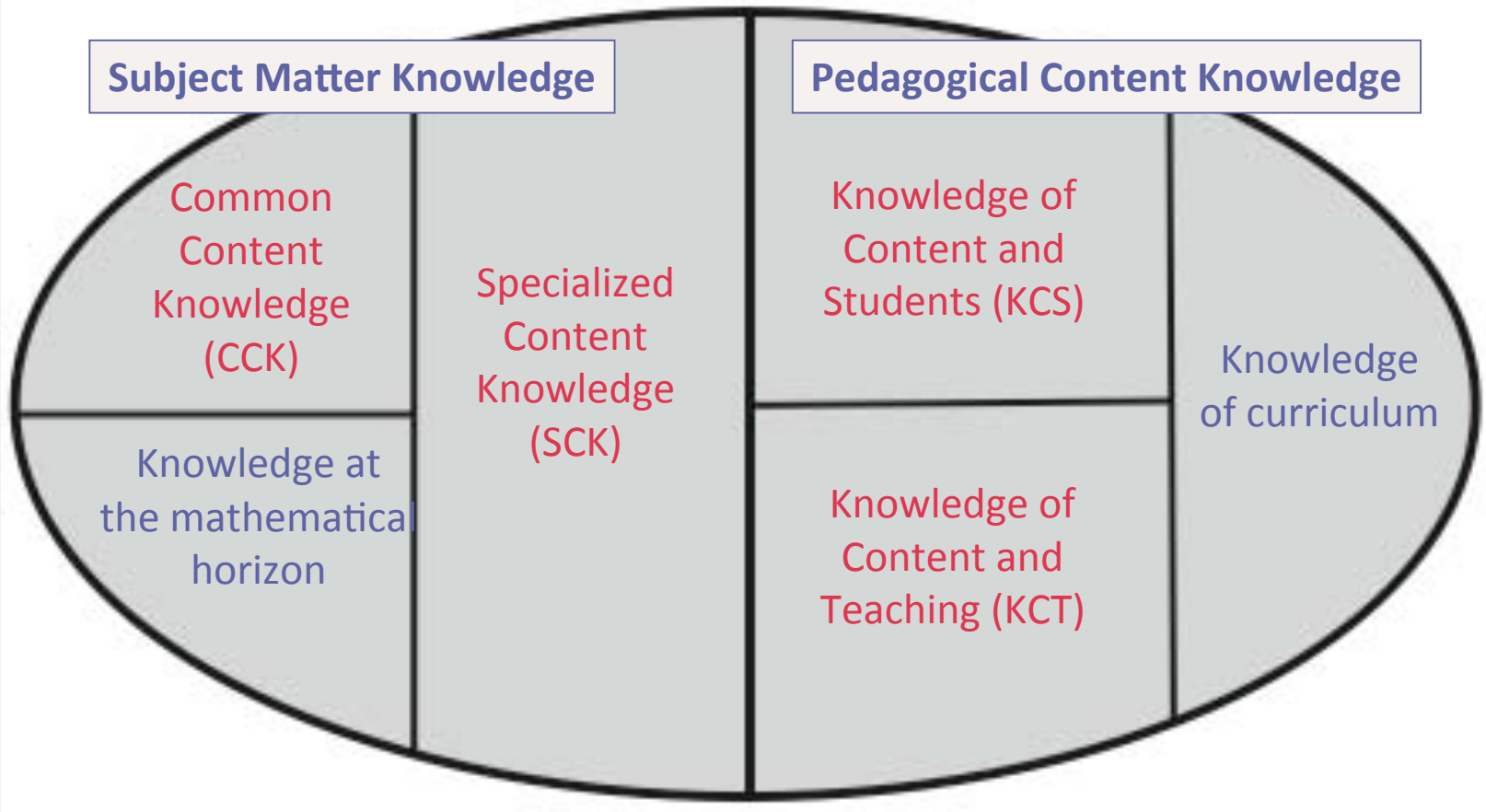
© 2009 Mathematics Teaching and Learning to Teach
School of Education • University of Michigan • Ann Arbor, MI 48109-1259 • (734) 615-7235 • mtlt@umich.edu

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

© 2009 Mathematics Teaching and Learning to Teach
School of Education • University of Michigan • Ann Arbor, MI 48109-1259 • (734) 615-7235 • mtlt@umich.edu

Mathematical knowledge for teaching



© 2009 Mathematics Teaching and Learning to Teach
School of Education • University of Michigan • Ann Arbor, MI 48109-1259 • (734) 615-7235 • mtlt@umich.edu

Common content knowledge (CCK)

Calculate:

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

© 2009 Mathematics Teaching and Learning to Teach
School of Education • University of Michigan • Ann Arbor, MI 48109-1259 • (734) 615-7235 • mtlt@umich.edu

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?

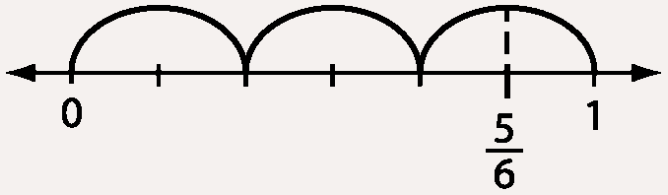
Does it work in general?

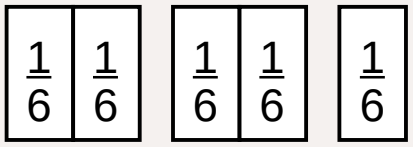
If so, why does it work?

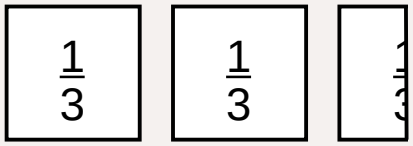
© 2009 Mathematics Teaching and Learning to Teach
School of Education • University of Michigan • Ann Arbor, MI 48109-1259 • (734) 615-7235 • mtlt@umich.edu

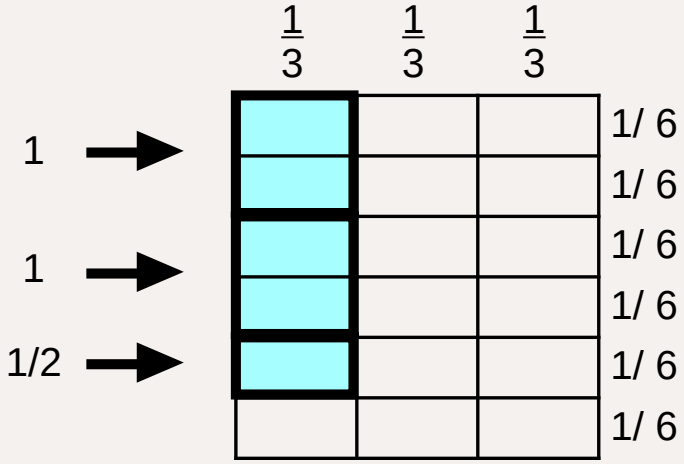
Specialized content knowledge (SCK)

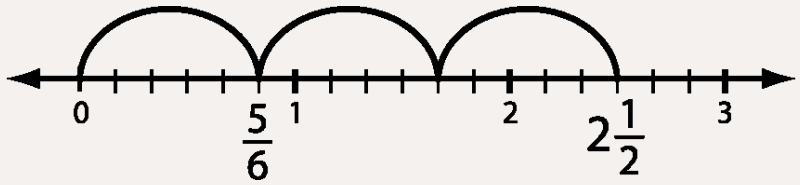
Which of these can be used to represent $\frac{5}{6} \div \frac{1}{3}$?











© 2009 Mathematics Teaching and Learning to Teach
School of Education • University of Michigan • Ann Arbor, MI 48109-1259 • (734) 615-7235 • mtlt@umich.edu

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

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?

© 2009 Mathematics Teaching and Learning to Teach
School of Education • University of Michigan • Ann Arbor, MI 48109-1259 • (734) 615-7235 • mtlt@umich.edu

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)

© 2009 Mathematics Teaching and Learning to Teach
School of Education • University of Michigan • Ann Arbor, MI 48109-1259 • (734) 615-7235 • mtlt@umich.edu

3. Developing and refining expertise in mathematics teaching practice

© 2009 Mathematics Teaching and Learning to Teach
School of Education • University of Michigan • Ann Arbor, MI 48109-1259 • (734) 615-7235 • mtlt@umich.edu

Core practices of teaching

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

© 2009 Mathematics Teaching and Learning to Teach
School of Education • University of Michigan • Ann Arbor, MI 48109-1259 • (734) 615-7235 • mtlt@umich.edu

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

© 2009 Mathematics Teaching and Learning to Teach
School of Education • University of Michigan • Ann Arbor, MI 48109-1259 • (734) 615-7235 • mtlt@umich.edu

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

SCHOOL OF EDUCATION UNIVERSITY OF MICHIGAN

© 2009 Mathematics Teaching and Learning to Teach
School of Education • University of Michigan • Ann Arbor, MI 48109-1259 • (734) 615-7235 • mtlt@umich.edu

Aspects of developing elementary mathematics specialists

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

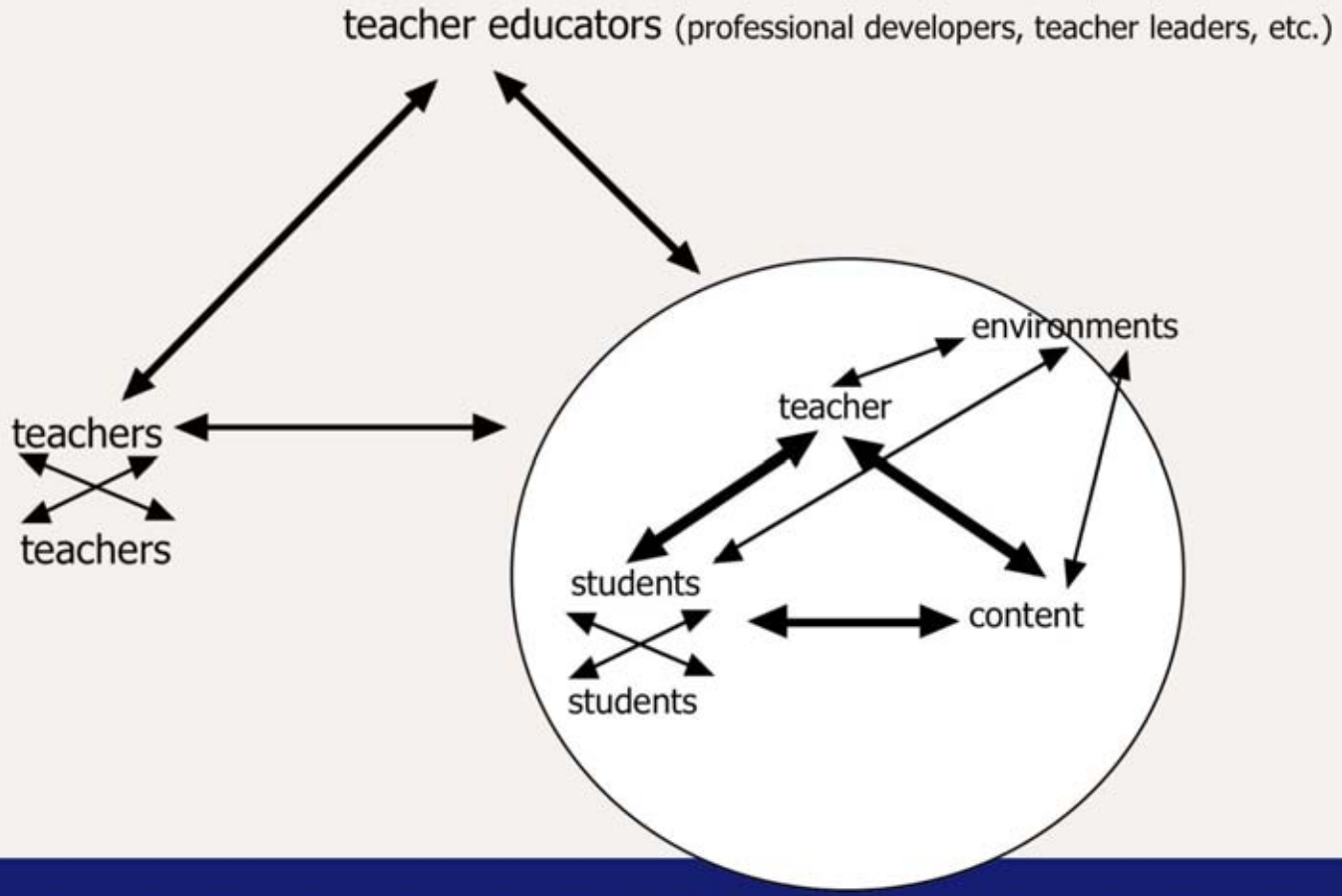
Aspect 2: Help accomplished teachers learn to have the perspective on their own practice and greater breadth, explicitness, and context for the teaching of elementary mathematics

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

SCHOOL OF EDUCATION UNIVERSITY OF MICHIGAN

© 2009 Mathematics Teaching and Learning to Teach
School of Education • University of Michigan • Ann Arbor, MI 48109-1259 • (734) 615-7235 • mtlt@umich.edu

Teaching practice as the content of professional expertise



© 2009 Mathematics Teaching and Learning to Teach
School of Education • University of Michigan • Ann Arbor, MI 48109-1259 • (734) 615-7235 • mtlt@umich.edu

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)

© 2009 Mathematics Teaching and Learning to Teach
School of Education • University of Michigan • Ann Arbor, MI 48109-1259 • (734) 615-7235 • mtlt@umich.edu

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

© 2009 Mathematics Teaching and Learning to Teach
School of Education • University of Michigan • Ann Arbor, MI 48109-1259 • (734) 615-7235 • mtlt@umich.edu

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

© 2009 Mathematics Teaching and Learning to Teach
School of Education • University of Michigan • Ann Arbor, MI 48109-1259 • (734) 615-7235 • mtlt@umich.edu

Thank you!

deborahball@umich.edu

© 2009 Mathematics Teaching and Learning to Teach
School of Education • University of Michigan • Ann Arbor, MI 48109-1259 • (734) 615-7235 • mtlt@umich.edu