Developing pre-service elementary mathematics teachers' knowledge bases through *Standards*-based curriculum materials

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Constructing Coherence Project

- Despite the prevalence of mathematics curriculum materials in elementary classrooms, most current mathematics methods courses and texts spend little or no time helping pre-service teachers (PSTs) learn to use curriculum materials.
- Investigates how elementary mathematics PSTs learn *about* and *from* interactions and engagements with Standards-based curriculum materials.
- Based on research (our own and others') on experienced teachers' use of curriculum materials

Constructing Coherence Project

- Tools and frameworks introduced in methods course
  - *Standards* – NCTM, State (& Common Core)
  - CGI Problem Types & Common Core Problem Types
  - Children's Solution Strategies (CGI)
  - Levels of Cognitive Demand
- Though designed for methods courses, also used *Standards*-based curriculum activities in content courses.
- We frame learning *about* and *from* curriculum materials through PSTs' development of:
  - Mathematical knowledge for teaching (Ball, Thames, & Phelps, 2008) and
  - Curricular knowledge (Shulman, 1986)

Today's focus

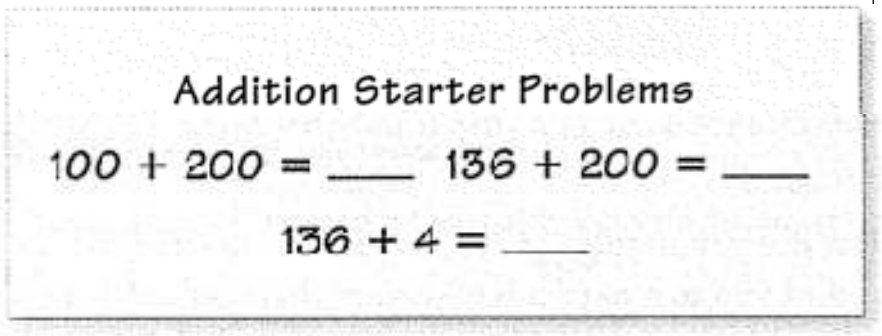
- Examining the Addition Starter Sentences (TERC, 2008) lesson activity from our Developing Addition Strategies Module.
  - A "taste" of the activity;
  - Share "learning about and from curriculum materials" data;
  - Discussion of developing teachers to teach Common Core Standards in this approach.

Addition Starter Problems: *Investigations*, Grade 3, Unit 3, Session 2.5

The Addition Starter Sentences *Investigations* lesson is designed to support children in developing alternate multi-digit whole number addition strategies:

Break Apart By Place, Adding One Number in Parts, and Changing the Numbers

- Solve each problem.
- Which of these is easiest for you to solve? Why?
- Consider 136 + 227 = ___
- What if we could use the Starter Problems as a first step to solving this problem, which would you choose? Why do you think that's a good start?
- Choose a starter problem, finish solving, and prepare to share your solution path.



Where do things go from here?

Investigations Lesson

- Children solve a series of six problems.
  - Each problem has three starter sentences and a final problem.
  - Children solve each starter sentence (mentally), choose one and solve the final problem.
  - Students *do not* have to use a starter sentence to solve the final problem.

Starter Sentences Activity

- PSTs solve same six problems as children would.
- Discuss the main strategies and PSTs' strategies in using starter sentences.
- Discuss *Investigations'* assessment "suggestions"
- Examine a revisiting of starter sentence strategies from *Investigation's* unit 8 lesson.
- PSTs examine 10 examples of student work solving 249 + 175. Classify by strategy and "rank" in order they would have students share solutions.

Connections to Common Core

- 2.NBT: **Use place value understanding and properties of operations to add and subtract.**
  - 7. Add and subtract within 1000, using concrete models or drawings and strategies based on place value, properties of operations, and/or the relationship between addition and subtraction; relate the strategy to a written method.
  - 8. Mentally add 10 or 100 to a given number 100–900, and mentally subtract 10 or 100 from a given number 100–900.
  - 9. Explain why addition and subtraction strategies work, using place value and the properties of operations.
- 3.NBT: **Use place value understanding and properties of operations to perform multi-digit arithmetic.**
  - 12. Fluently add and subtract within 1000 using strategies and algorithms based on place value, properties of operations, and/or the relationship between addition and subtraction.

Learning as evidence of mathematical knowledge for teaching

- Interpret responses through the constructs of subject matter knowledge and pedagogical content knowledge (Hill, Sleep, et al., 2007).

•Subject Matter Knowledge

- **Common content knowledge (CCK):** Mathematical knowledge taught to students
- **Specialized content knowledge (SCK):** Mathematical knowledge used in teaching but not taught to students
- **Horizon knowledge (HK):** Seeing connections within mathematical knowledge

•Pedagogical Content Knowledge

- **Knowledge of content and students (KCS):** Knowledge of how students learn content
- **Knowledge of content and teaching (KCT):** Knowledge of the design of instruction

Learning *about* curriculum materials

- How did students understand, react to and interact with the curricular materials? We examined this through a goals question posed after the class session:

  Depending on your purpose, you might have the following goals for students:

  1. Choose just one strategy and practice it
  2. Use more than one strategy to solve each problem
  3. Use more than one strategy across the problem set (i.e., use one strategy for one number combination and a different strategy for a different number combination)
  4. Learn and master all of the strategies

  If you were teaching the Addition Starter Sentences lesson, which of these goals would you have? Why? (You can use evidence from the materials or from your own experiences to support your choice).

Goals question data

- Data collected from three sections of an elementary methods course at two large Midwestern universities (N = 66).

Goal	# of PSTs
Choose just one strategy and practice it	8
Use more than one strategy to solve each problem	28
Use more than one strategy across the problem set	19
Learn and master all of the strategies	5
Multiple or all goals	5
Different goal	1

Digging a bit deeper

- From our standpoint, we would want children to be able to choose a strategy based upon the numbers in the problems. Therefore, we viewed Goal 3: Use more than one strategy across the problem set, as an ideal response to this question.
  - We found that 19 of the 66 (28.8%) selected this goal.
- We also wanted to examine the PSTs' reasoning behind the goal they selected; both to see who had "right" answers for the "wrong" reasons as well as "wrong" answers for the "right" reasons.

Examining reasons

- As we examined the PSTs' reasons for their goal choice, we realized that the curriculum materials were positively impacting what PSTs believed about introducing students to multiple strategies for solving problems.
- In spite of our initial data which showed only 19 of 66 PSTs selected our ideal goal for the lesson, the majority of PSTs (62 of 66) gave reasons for their goal that support student-centered and *Standards*-based mathematics teaching tenets.
- Only three PSTs suggested it was inappropriate to expose children to multiple ways of solving problems.

Examining reasons (N=65)

- Students *should* know and understand how to use multiple strategies because:
  - students should be able/allowed to use a strategy that works best for them (N=27);
  - students should be able/allowed to use a strategy that works best for the problem (N=16);
  - knowing multiple strategies develops flexibility in solving and checking work (N=17);
  - knowing multiple strategies develops understanding that there are multiple ways to do mathematics (N=2).
- Students *should not* know and understand how to use multiple strategies because:
  - students can get confused by seeing too many strategies (N=2);
  - it is not practical for students to master all of the strategies (N=1).

Conclusions -- Learning *about*

- As these curriculum materials are infused with and influenced by the *Standards* (and other) documents, using these materials with PSTs in our methods courses has allowed them to understand, develop, and reinforce some important teaching and learning ideas:
  - Common strategies children develop for adding multi-digit numbers (knowledge of content and students);
  - Structure of tasks to promote development of these strategies (knowledge of content and teaching);
  - The importance of developing computational fluency (knowledge of content and teaching).

Learning *from* curriculum materials

- In a separate activity, PSTs were also asked to respond to two reflection questions, designed to shed light on what they had learned from the curricular materials:

1. What did you learn about how you think about or solve addition problems?
2. What did you learn about how children think about or solve addition problems?

Results

- 63 responses were examined for evidence of the facets of MKT.
- Every PSTs response demonstrated evidence of development of some aspect of MKT.
- KCS and CCK were most frequently represented.

MKT Construct	# Responses with Evidence
Knowledge of content and students	60
Common content knowledge	59
Knowledge of content and teaching	15
Specialized content knowledge	8
Horizon knowledge	0

Knowledge of Content and Students (KCS)

The majority of PSTs' responses (60/63; 95.2%) demonstrated evidence of developing knowledge of content and students. These responses were largely examples of knowledge of how children learn mathematics.

Knowledge of how children learn mathematics	Frequency
Children solve problems in ways that make sense to them	8
Children's thinking is different from adult thinking	9
Children have many different ways of solving problems	41
Children can learn from other student's solutions	1
Children are capable of more than we give them credit for	1
No evidence of KCS	3

Common Content Knowledge (CCK)

The majority of PSTs responses (59/63; 93.7%) demonstrated evidence of developing common content knowledge. These responses were largely examples of the ways they preferred to solve addition problems.

Knowledge of solving addition problems	Frequency
Break apart by place	15
Change the numbers	12
Add one number in parts	3
Flexibly use more than one strategy	14
Use the standard algorithm	10
Learned new methods; no preference given	5
No evidence of CCK	4

Conclusions – Learning *from*

- The Addition Starter Sentences activity demonstrated PSTs have the ability to learn from their experiences with *Standards*-based curricular materials.
  - In terms of pedagogical content knowledge, the activity provides opportunity for PSTs to develop knowledge of content and students and knowledge of content and teaching.
  - In terms of subject mater knowledge, the activity provides opportunity for PSTs to develop common content knowledge and specialized content knowledge, but did not seem to afford development of their horizon knowledge.
  - Perhaps including a follow up activity that allows PSTs to relate the addition starter sentences strategies to the traditional algorithm would provide opportunity to develop this aspect of MKT.

Discussion

- How can *Standards*-based curriculum materials help inform the mathematical preparation of PSTs in the era of the Common Core?
  - Questions or comments
- Thanks for attending!

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References

- Ball, D.L., Thames, M.H. & Phelps, G. (2008). Content knowledge for teaching: What makes it special? *Journal of Teacher Education 59(5): 389-407.*
- Shulman, L.S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher 15(2): 4-14.*
- TERC (2008). *Investigations in Number, Data, and Space (Grade 3, Unit 3): Collections and travel stories. Glenview, IL: Pearson Scott Foresman.*