Differentiating Mathematics Instruction with Middle School Students: Findings in Progress

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Describe IDR²eAM project

Share features of DI we are experimenting with

Give example of this experimentation

Describe our analytical process and invite advice about it
The IDR$^2$eAM Project

- **Investigating Differentiated Instruction and Relationships between Rational Number Knowledge and Algebraic Reasoning in Middle School**

- **Research goals:**
  - To investigate how to differentiate mathematics instruction for middle school students operating with at least two different levels of reasoning.
  - To understand how students’ rational number knowledge and algebraic reasoning are related for each of these mathematical thinkers.
  - In later years of the project we will also be investigating how classroom teachers learn to differentiate instruction.
What are constraints in and affordances for differentiating mathematics instruction for middle school students?

How do students operating with different multiplicative concepts use their rational number knowledge to develop algebraic reasoning, and vice versa?

How does DI impact students and teachers, both cognitively and affectively?

How do teachers develop understanding of and skill at differentiating mathematics instruction for middle school students at different levels of reasoning?
Project Timeline

- **Years 1-2:** Conduct design experiments with groups of nine 7th and 8th grade students with diverse cognitive characteristics.
  - We began retrospective analysis of Year 1 data in summer and fall 2014.
  - We are in our third, iterative experiment in spring 2015.

- **Year 3:** Form a study group with 10-15 middle school classroom teachers in Indiana to explore how to differentiate mathematics instruction in whole classrooms.
  - We will also continue retrospective analysis of Year 1-2 data.

- **Years 4-5:** Co-teach with classroom teachers in classroom design experiments to explore differentiated instruction in topics related to rational numbers and algebraic reasoning.
How do we define differentiated instruction?

- Proactively tailoring instruction to students’ different learning needs, such as students’ readiness and cognitive abilities, interests, and learning profiles and backgrounds (Tomlinson, 2005) while trying to develop a cohesive classroom community.

- We are focused on students’ cognitive diversity; our definition/characterization of DI is under development.

- An alternative to…
  - Tracking
  - Individualized instruction for all
  - The same instruction for all
  - Labeling one way of thinking as “normal” and others as “advanced” or “slow” and making adjustments for those thinkers.
Features of DI in Years 1-2

1. On-going formative assessment
2. On-going exploration of “big” mathematical ideas and goals (for teacher and project team)
3. Mathematics problems with choices: e.g., Parallel Tasks
4. Flexible and intentional small groups
5. Student work in small groups
6. Whole classroom discussion about a topic, across different problems
Corn Stalk Tomato Plant Heights Problem

A tomato plant and corn stalk are growing in the garden, each of unknown height. The height of the corn stalk is 5 times the height of the tomato plant.

- Draw a picture of this situation and describe what your picture represents.
- Write an equation for this situation that relates the two heights. Explain what your equation means in terms of your picture.
- Can you write another, different equation that relates the two heights? Explain what your equation means in terms of your picture.

Fern Sunflower Heights Problem

A fern and sunflower are growing in the garden, each of unknown height. The height of the sunflower is 3/5 the height of the fern.

- Draw a picture of this situation and describe what your picture represents.
- Write an equation for this situation that relates the two heights. Explain what your equation means in terms of your picture.
- Can you write another, different equation that relates the two heights? Explain what your equation means in terms of your picture.
“Approximate” Multiplicative Relationships

- Tim: “Five tomatoes equals approximately corn stalk height.”

- The relationship stays as approximate until we measure the heights of the plants and get actual numeric values.

- Similar thinking was also observed in other students’ reasoning with multiplicative relationships between unknowns.
What problem situation might Tim, and others like him, view as definite?

Measuring a single unknown with two different measurement units.

E.g.,: 5 toothpick lengths fit into a skewer length. Imagine measuring the height of the room in each of these units.

If \( x \) = # of toothpicks that fit into height of room and \( y \) = # of skewers that fit into height of room, \( 5y = x \)
Results?

- Unknown right now.

- Informally/anecdotally:
  - No more mention of “approximate” across two more experiments.
  - However, some students still have difficulty structuring relationships between unknowns in pictures and notation.

  - Pedagogical benefit: Students have to think a lot about the meaning of the letters. It is easy to write $5x = y$ thinking that $x$ is a “toothpick” and $y$ is a “skewer.”

  - Research benefit: We can see pretty clearly the extent to which the letters represent **quantitative** unknowns for the students.
Our Analysis Process, initially:

- Initially:
  - Student portraits (the beginning of second-order models)
  - Open coding of episodes (video data) by hand to track functioning of DI
    - Open coding using ATLAS.ti (about 2 months)

- Our assessment of initial analysis:
  - Captured student thinking well
  - Captured aspects of teacher-student interactions pretty well
  - Did not seem to capture student-student interactions, which we are now viewing as an important part of DI

- Bigger problem: Analysis of student thinking was separate from analysis of video for DI…
Must keep analysis of student thinking and analysis of DI together…
Seeking Advice

Is the change we’ve described from the fall experiment to the spring experiment about differentiating mathematics instruction (for you)?
THANK YOU!

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