Factors Influencing Middle Grades Students' Algebra Learning: Multiple Research Perspectives

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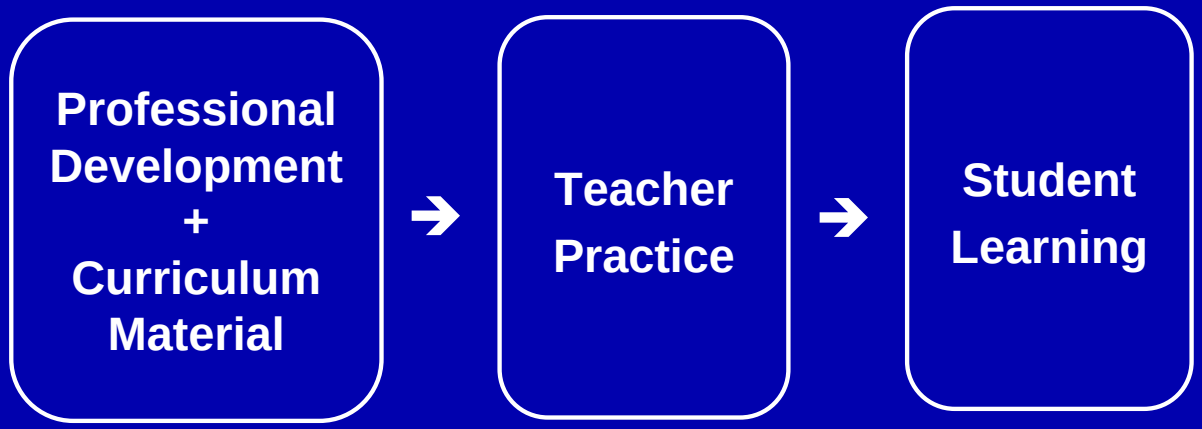
Logic Model of IERI Study



All focused on the same mathematical learning goal.

• Our ultimate goal is student learning of specific mathematics ideas and skills (which we refer to as learning goals).
• According to our model, teaching affects student learning and professional development affects teaching. Curriculum materials affect student learning directly and through the support they provide for teachers.
• We are seeking to learn if a relationship exists between teaching practice and student learning, between curriculum materials and student learning, and between professional development and teaching.
• At the same time we are exploring the effect of various professional development activities on teacher practice, with the intent of formulating testable hypotheses.

Unique Features of the Study

- Focusing all aspects of the study on specific learning goals increased chances of having and detecting an effect.
- Videotaped lessons enabled repeated examination of teaching by multiple observers.
- Well-defined criteria and indicators enabled consistent and valid judgments of teaching quality.

Learning goals defined at a fine grain size, such as understanding the role of symbolic equations in representing change over time or in relationship to other variables (versus topics like “algebra” or “equations”), unpacking the learning goal to key ideas and designing assessments to measure student understanding of them (versus using only an existing test that devotes 1-2 questions to the targeted ideas), examining teaching of lessons that target those key ideas (versus algebra teaching in general), and focusing professional development on the teaching of that specific content (versus on generic teaching strategies and expecting teachers to apply them).

• Permanent record of teaching (versus mainly self reports or notes from live observations)

• Well defined criteria, with indicators and examples/counter examples used to train reviewers and check their judgments

Algebra Learning Goal

Symbolic equations can be used to summarize how the quantity of something changes over time or in response to other changes.

Learning goal source is *Benchmarks for Scientific Literacy* (AAAS). This learning goal is considered central to beginning algebra, and is embedded in the state standards of Delaware and Texas, the two locations for the study.

For each of 3 years, we

- Provided professional development on teaching the concept of change to 7th and 8th grade algebra teachers.
- Videotaped 3-5 lessons per teacher on the algebra concept of change.
- Assessed 2500 students in videotaped classes, using a test we designed to measure students' understanding of the algebra concept of change.

41 teachers, 240 classes videotaped.

Research Question

What is the contribution of curriculum materials, teaching, and professional development to improving students' understanding of the algebraic concept of change?

Measures

Curriculum materials: high or not high rating on textbook evaluations

Professional development: number of days of participation per year

Teaching: numerical ratings on indicators of 5 different instructional criteria

Student learning: scores on pre and post tests

PD was 1-2 days in the first year, then 5-7 days in each of the other two years

Curriculum materials were rated in an earlier AAAS study (4 materials used in the study, 2 were rated high, one moderate and one low)

Key Criteria (Teaching)

- **IVC. Representing ideas effectively**
- **VA. Encouraging student explanations**
- **VB. Asking guiding questions**

These three criteria occurred with sufficient frequency to use in the quantitative analysis, while two other criteria dealing with pre-assessment and post-assessment did not.

Significant Contributors to Learning

- **Curriculum materials (Higher rated materials contributed more than lower rated materials)**
- **Teaching that guides student interpretation and reasoning (Asking Guiding Questions)**

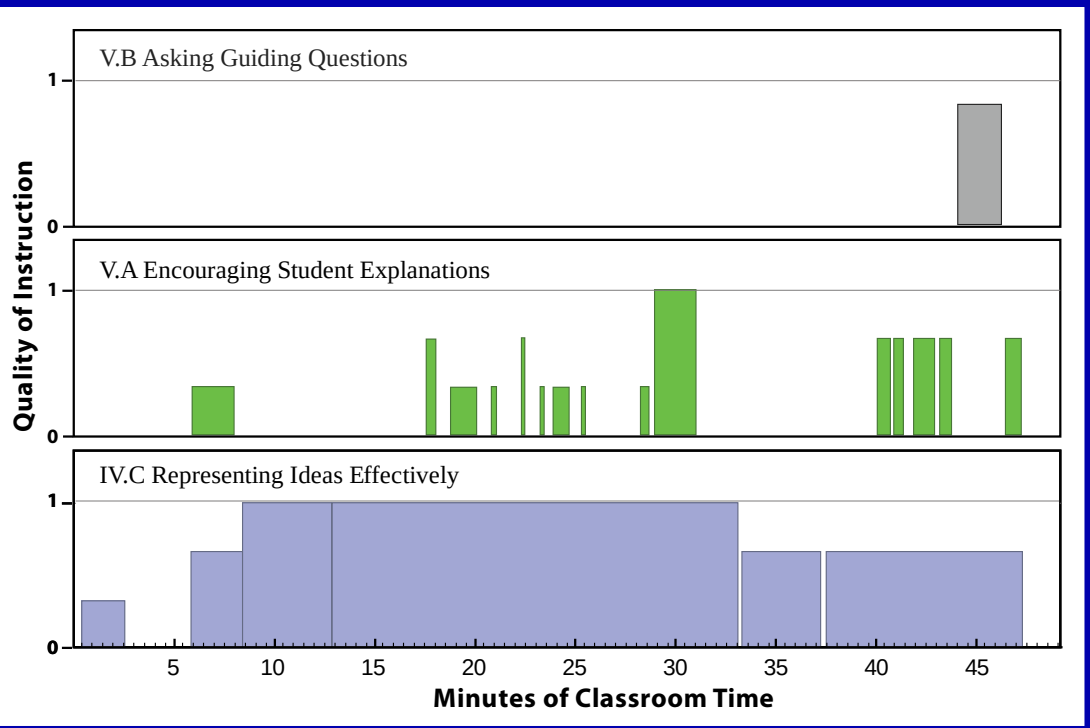
Multi-level structural equation modeling was used on measures of curriculum materials, professional development, teaching, and student learning. Results show significant effects on learning from use of higher rated curriculum materials and higher scores on the Asking Guiding Questions criterion.

Case Study of Teaching

	Teacher A	Teacher B
Curriculum Material	*Connected Mathematics*	*Connected Mathematics*
Teaching experience	At least 10 years	At least 10 years
Context	Suburban	Largely urban
Teaching Quality (Encouraging explanations)	Above mean both years	Above mean both years
Teaching Quality (Guiding reasoning)	Below mean both years	Above mean both years
Student learning and learning gains	Above mean year 1; below mean year 2	Above mean both years

Two teachers with similar backgrounds and same curricular materials are compared for their use of two of the instructional criteria: Encouraging student explanations and asking guiding questions).

Teacher A Lesson Graph



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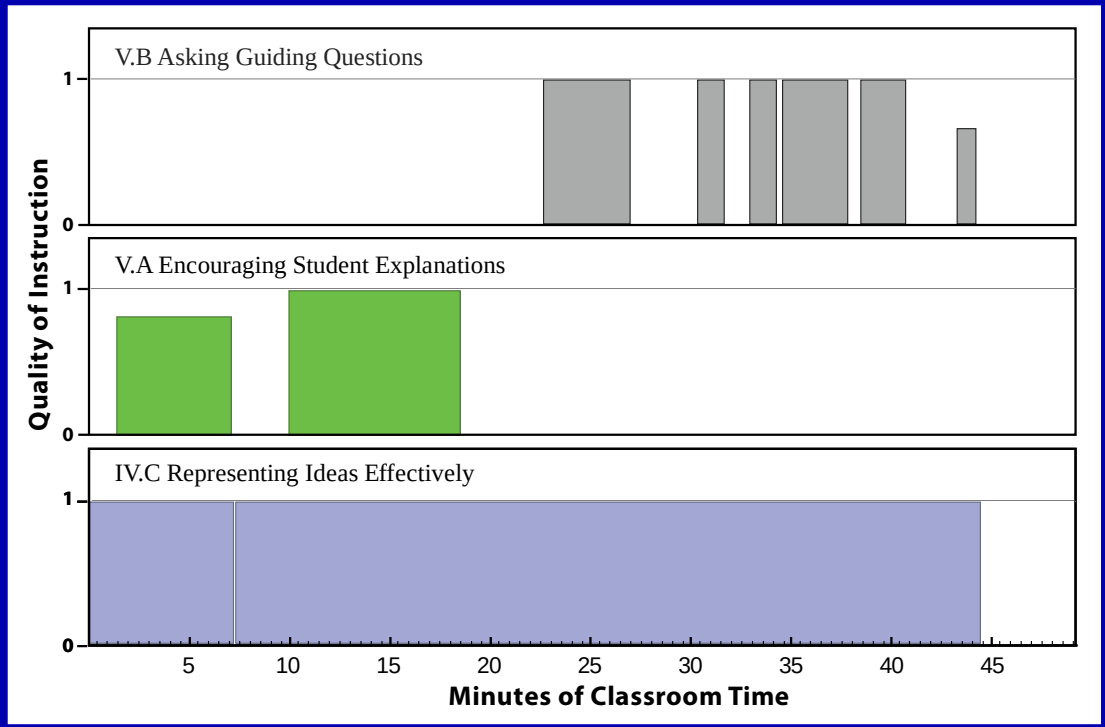
These are graphs of the video analysis for a single lesson, with the minutes on the horizontal axis and the weighting of each criterion on the vertical axis. The blue boxes show how much time the teacher spent on the learning goal. The height of those boxes indicates how accurate and accessible they are and to what extent the teacher used the representations to promote conceptual understanding of the learning goal. Above that is V.A, Encouraging Student Explanations, and above that, Asking Guiding Questions. An interpretation of this graph is that the teacher used most of the available class time on the learning goal, with moderately strong scores on use of representations. She had brief interactions with students during which she encouraged them to express their ideas, but she either limits their expressions to low-level responses or does not encourage more than a few students. She has only one encounter with student(s) who have a dilemma, and is moderately successful at asking guiding questions during that single encounter.

Teacher B Lesson Graph



Please note that IV.C., the representation criterion, addresses the learning goal and can be coded simultaneously with V.A. and V.B. which, however, are mutually exclusive. An interpretation of this graph is that the teacher uses nearly every minute of the class to focus on the learning goal, using representations to promote conceptual understanding. She has two episodes during which she encourages student explanations, one more successful than the other. As the lesson progresses, many students encounter dilemmas. The teacher is highly successful at asking guiding questions, listening to students and asking responsive and persistent questions that guide their understanding.

Discussion

- Uniqueness of focusing all aspects of the study on a clearly defined learning goal
- Importance of both quantitative & qualitative analysis
- Our analysis needs to continue . . .

We also have data for 6th grade teachers on a Number learning goal and data from grades 6-8 for all teachers for a learning goal on Data Analysis. Results of these analyses are underway.

To access the AERA paper, visit

http://www.project2061.org/publications/articles/IERI/algebralearning.pdf