Evaluation of Traditional and Reform Mathematics Curricula

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Applying Multiple Social Science Research Methods to Educational Problems: A National Forum

The National Academies, Washington, DC

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Overview

1. Context – Reform Mathematics Curricula
2. CPMP Evaluation Study
   a. Data Collection Using Mixed Methods
   b. Three Methodological Challenges
      - Opportunity to Learn
      - Capturing Students' Thinking
      - Fidelity of Implementation
3. Conclusions and Recommendations

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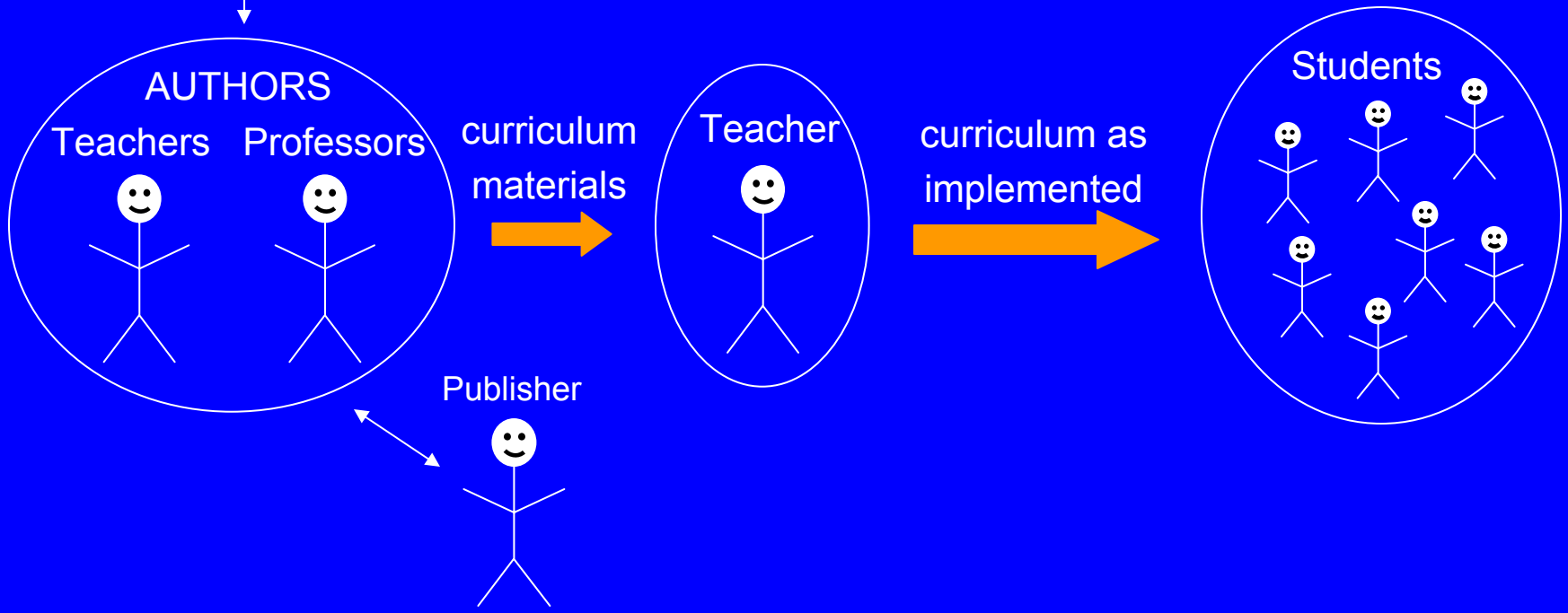
Context – Reform Math Curricula

NCTM Standards (1989)
Broad vision of mathematical content and pedagogy for Grades K-12

NSF $



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Naïve Answer: Just give kids math tests!

Which mathematics curriculum works best?

Naïve Answer: The one where kids score highest!

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CPMP Evaluation Study

Huntley, M. A., Rasmussen, C. L., Villarubi, R. S., Sangtong, J., & Fey, J. T. (2000). Effects of *Standards*-based mathematics education: A study of the *Core-Plus Mathematics Project* algebra and functions strand. *Journal for Research in Mathematics Education*, *31*, 328–361.

Purpose of the Research

To compare the effects on students of the CPMP approach to algebra with the effects of more conventional high-school mathematics curricula.

Main Research Question

What is the algebraic understanding, skill, and problem-solving ability of CPMP and control students ending their third year of high-school mathematics?

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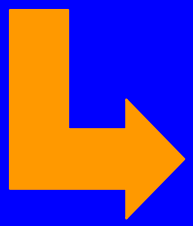
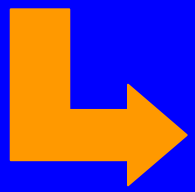
Data Collection Using Mixed Methods: Quantitative and Qualitative Data

Students' Learning of Algebra



Battery of paper-and-pencil assessments

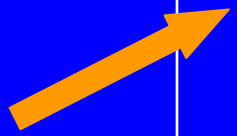
Curriculum Implementation



Interviews with teachers

Mixed-Method Design Matrix (Johnson & Onwuegbuzie, 2004)

Paradigm Emphasis	Time Order: Concurrent	Time Order: Sequential
Equal Status	QUAL+QUAN	QUAL→QUAN QUAN→QUAL
Dominant Status	QUAL+quan	QUAL→quan qual→QUAN
Dominant Status	QUAN+qual	QUAN→qual quan→QUAL



Value of Using Mixed Methods: Interpreting Inconsistent Findings

Main Findings

- CPMP students are better at applied problem solving
- Control students are stronger at symbol manipulation

Exceptions

- Site 3 – control students outperformed CPMP students on all assessments
- Site 4 – CPMP students matched the performance of control students on algebraic symbol manipulation

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Three Methodological Challenges

1. Opportunity to Learn
2. Capturing Students' Thinking
3. Fidelity of Implementation

Other Challenges

Participants

- Who should be tested?
- How does one even go about soliciting sites for testing?
- How does one go about establishing comparability of groups?

Test Administration

- At what point in the school year should we administer the assessments?
- Who should administer them?
- How do we get students to take the assessment seriously?

Data Analysis

- How do we grade the papers?
- What is the appropriate unit of analysis?
- When do we employ statistical methods?
- How do we make sense of the results and report them so that they're understandable to others?

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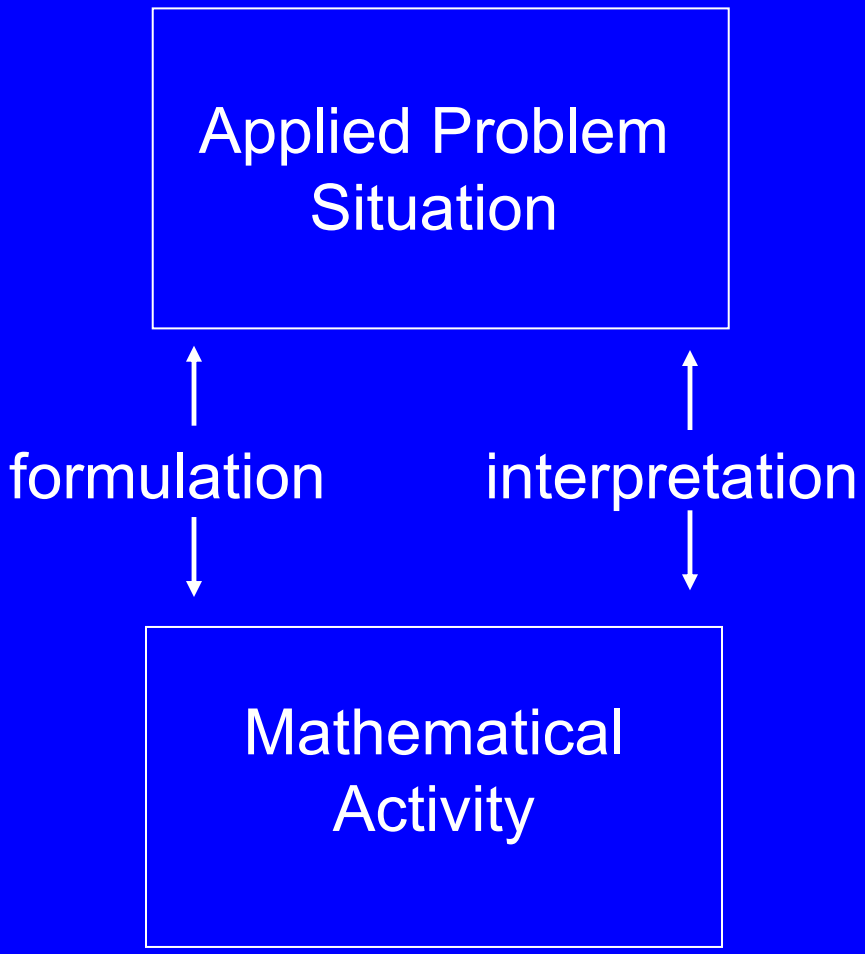
Challenge #1

How does one construct a fair assessment (one that is accessible to all students) in light of the different curricular approaches to algebra?

CPMP Approach to Algebra

- Emphasis on mathematical modeling
- Use of graphing calculators to support multiple representations of algebraic ideas
- Students work collaboratively on authentic problems
- Algebra is integrated with topics in geometry, statistics, probability, and discrete mathematics
- Topics are organized in a concept-then-skills-then-abstraction order
- Reduced attention to formal symbol-manipulation procedures

Schema of Mathematical Modeling



Three Main Components of Effective Algebraic Thinking

1. Mathematize quantitative problem situations
2. Using algebraic principles and procedures to produce results beyond information given
3. Interpreting results

Three Types of Assessments

1. Contextualized problem solving
2. Context-free symbolic manipulation
3. Problems requiring collaborative work on open-ended contextual problems

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Challenge #2

How does one ensure that the assessments capture students' thinking (what they know and are able to do)?

Format of Assessments: Paper-and-Pencil

Strength

Low cost, ease of administration

↓

Large number of participants

Weakness

Scant student written work

↓

Insufficient information about student reasoning and calculator use

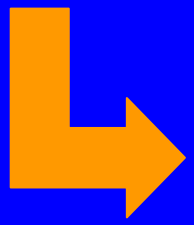
Clinical Interview Study

How do 11th-grade students solve algebra problems?

- What are their reasoning processes?
- How do they use graphing calculators?

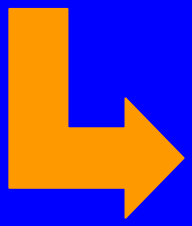
Data Collection for Clinical Interview Study

Students' Algebraic Reasoning



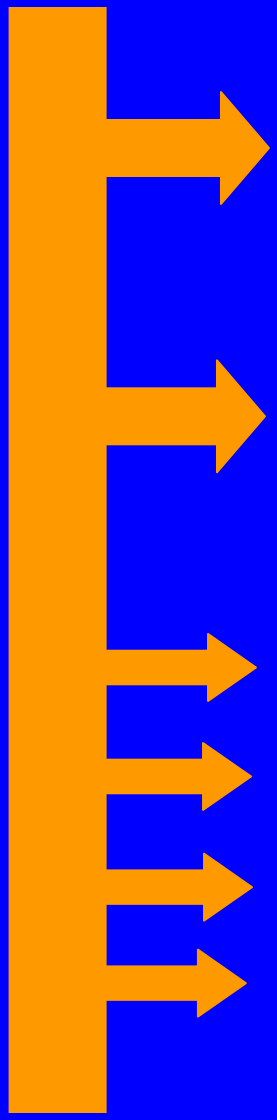
Task-Based Student Interviews

Calculator Use During Instruction



Teacher and Student Surveys

Students' Learning of Algebra



Evaluation Study

Battery of paper-and-pencil assessments

Study of Students' Algebraic Reasoning

Clinical Interviews

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Challenge #3

How does one know that true (faithful) curricular implementation is being assessed?

Teacher Interview Questions

- Additions to and deletions from intended curriculum
- Typical classroom instructional practices
- Use of calculators
- Reactions to the CPMP curriculum
- Assessment practices

Teacher Interviews

Strengths

Low cost, teacher comfort

Weaknesses

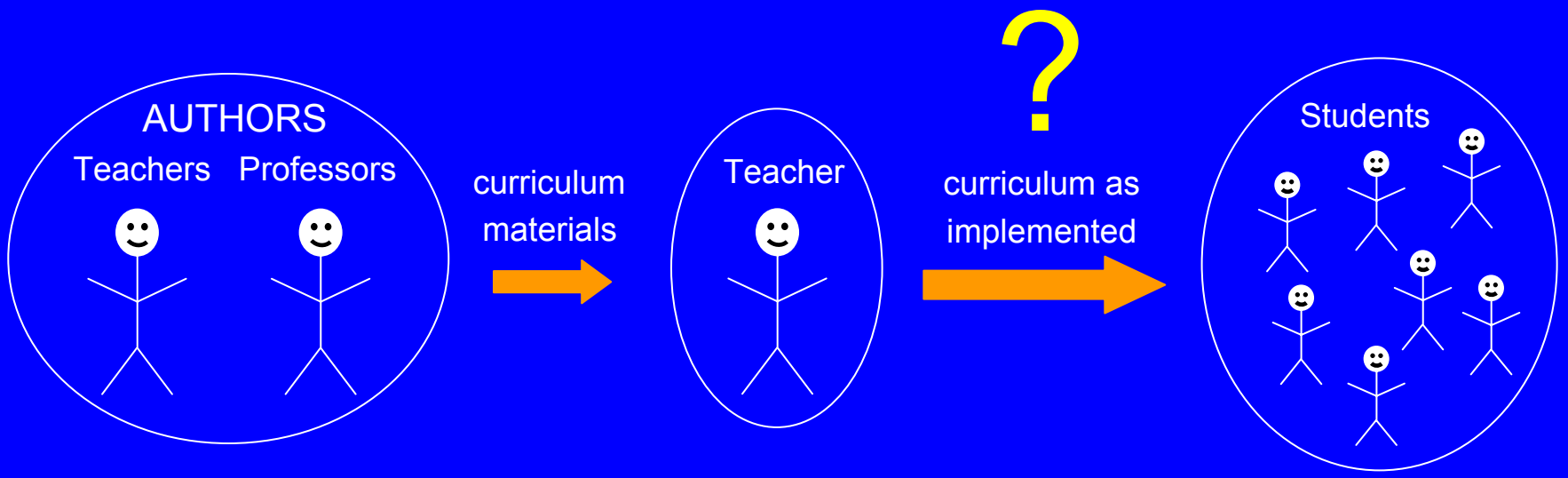
Self-report data

Insufficient information about classroom instructional practice

A Closer Look at Fidelity of Implementation

Existing research suggests reform mathematics curricula are positively impacting students and teachers.

However, most impact studies (e.g., Huntley et al., 2000) fail to adequately address how reform curricula are being implemented.



“Teachers necessarily select from and adapt materials to suit their own students. This creates a gap between curriculum developers’ intentions for students and what actually happens in lessons. Developers’ designs thus turn out to be ingredients in—not determinants of—the actual curriculum.”

Ball & Cohen (1996, p. 6)

“Two classrooms in which the same curriculum is supposedly being ‘implemented’ may look very different; the activities of teacher and students in each room may be quite dissimilar, with different learning opportunities available, different mathematical ideas under consideration, and different outcomes achieved.”

Kilpatrick (2003, p. 473)

“To be effective, teachers must know and understand deeply the mathematics they are teaching and be able to draw on that knowledge with flexibility in their teaching tasks.”

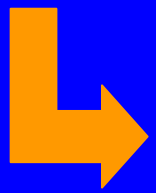
NCTM (2000, p. 17)

What does it mean to implement *[reform curriculum]* as the authors intend?

- What does it look like?
- How do you know it when you see it?
- Does it vary by content strand?
- In what ways does implementation of *[reform curriculum 1]* differ from implementation of *[reform curriculum 2]*?

Study of Fidelity of Implementation

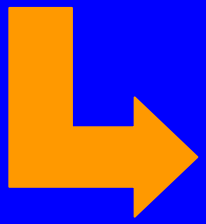
What does it mean to implement *Connected Mathematics* and *Math Thematics* the way the authors intend?



What are the essential characteristics and acceptable adaptations of *Connected Mathematics* and *Math Thematics* implementation?

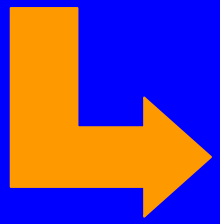
Data Collection for Study of Fidelity of Implementation

Curriculum Implementation



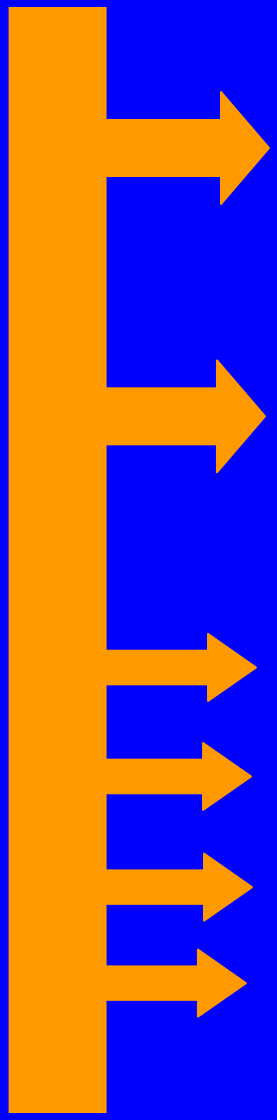
Observations of classroom practice

Beliefs about Curriculum



Interviews with authors, teachers, students

Curriculum Implementation



Evaluation Study

Teacher Interviews

Study of Fidelity of Implementation

Classroom Observations

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Naïve Answer: Just give kids math tests!

Informed Answer: It means conducting multiple studies using multiple methods.

Which mathematics curriculum works best?

Naïve Answer: The one where kids score highest!

Informed Answer: This is a complex question. Any curriculum is likely to work for some learning goals better than others, and under some conditions better than others.

Goal: To Develop Contrasting Profiles of Curricular Effects

Given the challenges that researchers face and the multiple methods required to meet the challenges, the results can be expected to be more complicated than whether a particular curriculum “works” or whether one curriculum is the best.