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Problem Statement

Teachers have access to an unprecedented amount of data. Student performance in mathematics is not changing.
• Data-related activities did not increase
• Teachers' use of data for changing their instructional practices did not increase
• Student achievement did not improve

Value Proposition
Learning progression-based classroom assessment practices can uniquely support teachers' decision making thereby improving students' mathematics outcomes.

What theories underlie this value proposition?
What assumptions do these theories impose?
What evidence is available to examine these assumptions?
What evidence are we missing?
Theory 1: Theory of Action for Formative Assessment Practices

- Classroom-based Data
- Student learning improves
- Teachers interpret data
- Teachers change instruction

Datnow, Pank & Kennedy-Lease, 2012; Gleason et al., 2010; Marsch, 2012

Assumptions
Data are relevant.
Data are informative.

Theory 2: Alignment Triangle: Curriculum-Instruction-Assessment

Pellegrino, Chudowsky & Glaser, 2001
Curriculum, instruction, and assessment are based on theories of learning. Theories of learning represent knowing in the domain and have a structure that is informative.

**Assumptions**

Corcoran, Mogat, & Rosher, 2009; Duschl et al., 2011

**Theory 3: Learning progressions represent the nature of knowing**

- **Entry KSAs**
- **Intermediary Steps**
- **Exit KSAs**

Conceptions: represent knowing in the domain
Order: conceptions progress in sophistication
Interconnections: conceptions interact
11/10/19

4: Equivalent Fractions

4.1: Representing Equivalence
4.2: Generating Equivalent Models
4.3: Equivalence with Magnitude
4.4: Lawfulness of Equivalence

5: Decimals

5.1: Decimals as Numbers
5.2: Decimal Notation
5.3: Decimal Comparison
5.4: Decimal Representation

6: Comparing Fractions

6.1: Numerator Reasoning with Model
6.2: Denominator Reasoning
6.3: Reasoning with Unlike Denominators

6.3: Using Division to Determine Equivalence

7: Conversion between Representations

7.1: Fraction and Decimal Equivalence
7.2: Fractions and Equivalent to Division
7.3: Equivalent to Division

Complexity of Content within Levels in the Learning Progression

- Structure can provide a framework for teachers’ interpretation of data
- Move away from dichotomous interpretations
- “They got it”
- “They didn’t get it”

Teacher-student Data
Teachers interpret data
Teachers change instruction
Student learning improves

Conceptions
What to teach and to what level of intensity
Why are students struggling
What to teach to address misconceptions or revise students’ initial mental models
How to recognize students’ misconceptions to promote conceptual change

Ordering
How to plan the learning sequence (e.g., from simple to complex)
Deeper understanding of misconceptions can influence the learning sequence
In what order to teach which concepts
How to evaluate student learning progress

Interconnections
What are students’ background knowledge
What pre-existing knowledge and skills can be integrated in add more depth or alternate
Understanding students’ misconceptions and patterns

Alonzo, 2018; Corcoran, Mogap, & Rishein, 2010; Duschl et al., 2011; Furtak, 2012; Ketterlin-Geller et al., 2019.
Assumption

Learning progressions are based on theoretical and empirical evidence.

Theory 4: Validity Argument Framework (Kane, 2006, 2013)

Scores from learning progressions-based classroom assessments

Scoring

- Closed to the observation tool
- Content representation
- Reliability of results
- Scaling models: appropriateness to interpretation/use

Generalization

- To untested content within the domain
- To future performance in the domain
- To performance in the domain (at a specific time)
- To different response models/and item formats

Extrapolation

- Beyond the tested domain to a broader definition of the same construct
- Beyond the context (ex: SAT predicts college readiness)
- Beyond the tested domain to an untested construct (ex: critical thinking skills)

Instructional decisions

Preliminary Review of Evidence

<table>
<thead>
<tr>
<th>Emphasis on ordering</th>
<th>Conceptions</th>
<th>Ordering</th>
<th>Interconnections</th>
</tr>
</thead>
</table>
### Sources of Evidence: Inferences and Outcomes

**Scores from learning progressions-based classroom assessments**

#### Scoring

**Conceptions**
- Content is relevant and representative of conceptions (Roberts et al., 2014)
- Item format elicits student thinking (Clements et al., 2007) and misconceptions (Ketterlin-Geller et al., 2019; Penuel et al., 2014)

**Order**
- Order is reproducible (e.g., Ketterlin-Geller et al., 2019; Lai et al., 2017; van Rijn et al., 2014), but progress varies for individual students (Wright, 2014)
- Complexity is difficult to disentangled from item difficulty (Lai et al., 2017)

**Interconnections**
- Content is sequenced from least complex to most complex (Ketterlin-Geller et al., 2019; Lai et al., 2017)

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#### Generalization

**Conceptions**
- High ability score is associated with low misconceptions but not the reverse (Bradshaw & Templin, 2012; Russell et al., 2009)

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#### Extrapolation

**Conceptions**
- Teachers used diagnostic data to identify misconceptions and help students reconceptualize content (Penuel et al., 2019)

**Order**
- Teachers did not use LP to identify prior knowledge or anticipate misconceptions; used LP to identify target (Wright, 2014)

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#### Instructional decisions

- Extrapolation
Conceptions
- What to teach and to what level of intensity
- Why are students struggling
- What to re-teach to address misconceptions or revise students’ initial mental models
- How to reorganize students’ knowledge to promote conceptual change

Ordering
- How to plan the learning sequence (e.g., next steps in instruction)
- Deepen understanding by engaging learners in more sophisticated ways
- In what order to teach which concepts
- How to evaluate students’ learning progress

Interconnections
- What are students’ background knowledge
- Which pre-existing knowledge and skills can be integrated to add more depth or elaborate
- Understand students’ discourse patterns

Call for New Sources of Evidence
- Expand range of research designs used to examine inferences
- Examine causal outcomes and consequential aspects of using data
- Explore utility of emerging technologies

Conclusions
- Theoretical propositions: integrate an aligned system of curriculum-assessment-instruction that is based on theories of learning
- Learning progressions: nature and structure can inform decisions
- Evidence:
  - Emerging
    - Primary sources are psychometric analyses associated with ordering
    - Emphasize scoring inferences
- New sources of evidence are needed to realize the value proposition
Forthcoming Special Issue: Empirical recovery of learning progressions
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Thank you!
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