iFAST Algebra: Improving Formative Assessment to Support Teaching in Algebra

NSF DRK-12 PI Meeting

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iFAST Research Team

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iFAST Algebra: Project Overview

- Improving Formative Assessment to Support Teaching (iFAST) in Algebra
  - 4-year project: 2013-2017

- Goal is to develop a professional development model and instructional resources to support middle grades teachers in meeting challenges set by CSSM for students’ learning of algebra
  - Articulate a learning trajectory of algebra content in CMP3 in a way that is interpretable and useful for teachers
  - Empirically determine key landmarks and obstacles that inform teaching of middle-grades algebra
A Focus on Formative Assessment

High-quality formative assessment practices:

• Enhance teaching effectiveness and student learning (Kingston & Nash, 2011)

• Enhance the learning process rather than simply capturing learning outcomes as summative assessments do (Black & Wiliam, 1998)

• Depend on:
  – clear learning goals
  – student learning trajectories
  – criteria for locating students along the trajectories
  – sharing of this info with students & using it to inform instructional decisions
Formative Assessment: A Working Definition

• Formative assessment is a process in which teachers monitor student progress toward learning goals, gather evidence of student learning, provide feedback to students, and adjust the teaching and learning activities in which they are engaged in order to make progress toward the desired learning goals (Black et al., 2004; Heritage, 2010)
A Focus on Learning Trajectories

• Learning trajectories describe how concepts and student understanding develop over time through instruction:
  – A researcher-conjecture, empirically-supported description of the ordered network of experiences a student encounters through instruction (i.e., activities, tasks, forms of interaction) in order to move from informal ideas through successive refinements of representations, articulation and reflection towards increasingly complex concepts over time (Confrey et al., 2008)

• A conceptual corridor incorporates the possibility of multiple pathways toward learning, as well as attention to landmarks, obstacles that students encounter along those pathways (Confrey et al., 2009)

• Curriculum programs (e.g., CMP3) propose hypothetical learning trajectories for student learning that are manifest in the order of units, investigations, problems across the school year
iFAST Algebra: Putting It All Together

- Learning trajectory work will inform our understanding of how students progress along trajectories
  - Identify conceptual corridor with respect to linear functions topics
- In turn, learning trajectory work will inform development of professional development model and instructional resources focused on formative assessment to be used with middle grades teachers
- We focus on the following research questions:
  1. What are changes in teachers’ learning trajectories as they engage with different formative assessment strategies?
  2. What are obstacles, landmarks middle grades students encounter with respect to linear functions and equations and topics?
Articulating Hypothetical Learning Trajectories in iFAST

Researchers develop hypothetical learning trajectories (HLTs) in mathematics based on:

1. Analysis of what is in the curriculum (e.g., Olsen, 2010)
2. Empirical study of how students learn mathematical concepts and procedures (e.g., Clements & Sarama, 2004)

iFAST draws from both approaches.
Student Performance on LF Interview

7th Grade

Correct  Partially correct  Incorrect  Blank or impossible to interpret

1.1A/E  1.1F  1.1G  1.1H  1.2  1.3  1.4  2.1AE  2.1F  2.1G  2.1H  2.2  2.3  2.4
Hypothetical Learning Trajectory for Linear Functions in CMP3
HLT: Transition from Proportional to Non-Proportional Linear Functions

Gr7-MSA-4: Write equations that represent linear relationships given specific pieces of information and describe what information variables and numbers represent

<table>
<thead>
<tr>
<th>Text</th>
<th>1.4 Using (negative slope) the walkathon money (non-proportional LF)</th>
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<tbody>
<tr>
<td>Note</td>
<td>A. Table→ [Qs: y-intercept and slope in context (e.g., money at the start of the project), generate Graph, write rule]</td>
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<tr>
<td></td>
<td>B. Graph → [Qs: y-intercept and slope in context, generate Table, write rule]</td>
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<tr>
<td>Year</td>
<td>LT Work</td>
</tr>
<tr>
<td>--------</td>
<td>--------------------------------------------------------------</td>
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<tr>
<td>AY 14-15</td>
<td>• Develop, administer student assessments</td>
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<td>• Map hypothetical, enacted LTs</td>
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<tr>
<td>AY 15-16</td>
<td>• Administer student assessments, interviews</td>
</tr>
<tr>
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<td>• Map enacted LTs</td>
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<tr>
<td>AY 16-17</td>
<td>• Administer student assessments, interviews</td>
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IFAST Professional Development

Year 3: Focus on FA in context of LTs
- FA Practices
- Connect to Practice

Year 2: Focus on FA w/ Student Data
- Working on the Content
- Analyzing Artifacts of Practice
- Connect to Practice
  - Create a Plan for Instruction
  - Enact Plan
  - Reflect on Plan

Year 1: General Focus on FA
- FA Practices
- Connect to Practice
  - Providing feedback that moves learning forward
  - Articulating learning goals and success criteria
  - Engineering class discussions and tasks that elicit evidence of student learning
Analyzing Student Work: A Process of Formative Assessment

1. Select Task
2. Analyze Task
3. Implement Task
4. Select Samples of Student Work
5. Make Decisions about Next Instructional Moves
6. Analyze and Make Inferences
7. Compare Samples
### Lesson Problems

**Tabbed page**

**Grade 7**

**Moving Straight Ahead**

<table>
<thead>
<tr>
<th>Lesson Problems</th>
<th>Associated ACE Problems</th>
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</thead>
<tbody>
<tr>
<td>Lesson Problem 1.3 (Student Version)</td>
<td>ACE Investigation 1 – Problem 11</td>
</tr>
<tr>
<td>Lesson Problem 2.3 (Student Version)</td>
<td>ACE Investigation 2 – Problem 5</td>
</tr>
<tr>
<td>Lesson Problem 4.2 (Student Version)</td>
<td>ACE Investigation 4 – Problem 2</td>
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</table>

**Grade 8**

**Thinking with Mathematics Models**

<table>
<thead>
<tr>
<th>Lesson Problems</th>
<th>Associated ACE Problems</th>
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<tbody>
<tr>
<td>Lesson Problem 1.2 (Student Version)</td>
<td>ACE Investigation 2 – Problem 4</td>
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<tr>
<td>Lesson Problem 2.2 (Student Version)</td>
<td>ACE Investigation 2 – Problem 35</td>
</tr>
<tr>
<td>Lesson Problem 2.4 (Student Version)</td>
<td>ACE Investigation 2 – Problems 22-25</td>
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</tbody>
</table>
When Rashida and Serena applied for jobs at Sandy’s, the owner gave them the following test questions to see if they could calculate charges correctly.

1. Explain what the numbers in the equations $c = 0.15t + 2.50$ tell you about the situation.
2. How much does it cost to rent a canoe for 25 minutes?
3. A customer is charged $9.25. How long did he use the canoe?
4. A customer has $6 to spend. How long can she use a canoe?

The owner gave Rashida a graph of $c = 0.15t + 2.50$ and asked her how it could be used to estimate answers to Question A. How could Rashida respond?
iFAST Algebra Tools: Select, Compare, Analyze Student Work

Problem 2.4

When Rashida and Serena applied for jobs at Sandy’s, the owner gave them the following test questions to see if they could calculate charges correctly.

1. Explain what the numbers in the equation $c = 0.15t + 2.50$ tell you about the situation.
   - $0.15$ is the slope
   - $2.50$ is the y-intercept

2. How much does it cost to rent a canoe for 25 minutes?

Please answer the following questions for the second sample work:

1. What mathematical understandings does this sample of work reveal?
   - [ ]

2. What misconceptions does the work reveal?
   - [ ]

3. What evidence supports these claims?
   - [ ]

4. Where would you place this student along a trajectory of learning these concepts?
   - [ ]

5. What would be your next instructional moves for this student?
   - [ ]
What Have We Learned

- Cohort 1 teachers have their own “learning trajectories” for understanding of, enactment of formative assessment processes

- Preliminary data analysis indicates:
  - Cohort 1 teachers demonstrate significant gains in development of math knowledge for teaching across both years (MKT instrument)
  - Analyzing student work, making inferences about student understanding is challenging for Cohort 1 teachers
    - Little to no change in teachers’ performance on TASK instrument across two years

- Lingering Questions:
  - How do you represent the learning trajectory, together with the associated anchor problems and obstacles, in a way that is useable for teachers?
    - Pilot online algebra tools in coming school year