An Overview of the LPPSync project
(Learning Progress Profiles Synchronized for Wireless Devices)

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Outline of Talk

• Learning Trajectories

• Interactive Diagnostic Assessments

• Pilot Study

• Discussion and Conclusions
Research Program Goals

• To construct learning trajectories for K-8 rational number reasoning
• To construct diagnostic assessments to assess rational number reasoning
• To unpack the Common Core Standards for Mathematics from a learning trajectories perspective (http://www.turnonccmath.com)
LPPSync Video
Definition of Learning Trajectory

• a researcher-conjectured, empirically-supported description of the ordered network of constructs a student encounters through instruction (i.e. activities, tasks, tools, forms of interaction and methods of evaluation), in order to move from informal ideas, through successive refinements of representation, articulation, and reflection, towards increasingly complex concepts over time (Confrey et al., 2009).
Learning Trajectories

• Based on synthesis of existing research, further research to complete the sequences, and a validation method based on empirical study.

• Recognize that students enter instruction with relevant yet diverse experiences, which serve as effective starting points.

• Assume a progression of cognitive states from simple to complex, which is not linear, but neither is it random, and it can be sequenced and ordered as “expected tendencies” or “likely probabilities”.

• Assumes well-ordered set of tasks (curriculum), instructional activities, interactions, tools, and reflection.
Research Program Methodology

Building a Validity Argument for the LT

• Conduct literature synthesis and first approximation of LT
• Design tasks and conduct cross-grade clinical interviews, revise LT in light of interviews
• Design, pilot, and field test diagnostic assessment items
• Analyze field test results using Item Response Theory (IRT) Modeling
• Design IGEs (item generation environments) for Diagnostic Assessments (LPPSync)
<table>
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<tr>
<th>Task Classes</th>
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**Proficiency Levels**

16. Generalize: $a$ among $b = a/b$
15. Distributive property, multiple wholes
14. Direct-, Inverse- and Co-variation
13. Compositions of splits, mult. wholes
12. Equipartition multiple wholes
11. Assert Continuity principle
10. Transitivity arguments
9. Redistribution of shares (quantitative)
8. Factor-based changes (quantitative)
7. Compositions of splits; factor-pairs
6. Qualitative compensation
5. Re-assemble: $n$ times as much
4. Name a share w.r.t. the referent unit
3. Justify the results of equipartitioning
2. Equipartition single wholes
1. Equipartition Collections
Diagnostic Assessments (Confrey et al., 2011)

• Provide observable indicators of covert ordered states of development of cognitive reasoning of "big ideas" over time.

• Include common obstacles, landmarks, transformative states, and essential components of key ideas; including healthy growth indicators and evidence of deficits, gaps or misconceptions.

• Based on explicit cognitive models informed by empirical research.

• Intended to assist students, teachers, and others in determining what instructional activities and tasks are needed to foster further learning.
Interactive Diagnostic Assessment System (IDAS)

- *Interactive Diagnostic Assessment Systems:*
  - Provide users with scientifically valid information about student learning over time with respect to an underlying cognitive model of learning about a core idea or set of related ideas.
  - Periodically capture, record, and evaluate students’ strategies, representations, ideas, and transformational states as they move from novice to sophisticated thinking.
  - Provide information to teachers about student ideas, documents student progress over time and assists students and teachers in engaging in formative assessment practices.
  - Elicit diverse student thinking, classroom discourse, and supports personalizing instruction.
  - Provide students directly with insight into their own progress relative to the cognitive model.
  - Support and enrich--not displace--interactive and engaging instructional practices and pedagogies.
Suggested Recommendations for IDAS (Confrey et al., 2011)

- Connected to LTs and provide instructional guidance
- Co-developed by various partners (e.g., mathematics educators, measurement experts, software engineers, and teachers)
- Aligned to Common Core
- Designed to capitalize on new technological innovations
LPPSync System

Diagnostic Assessment System Design Considerations—

- Learning Trajectories-based data collection
- Item Generation Environments (IGEs) generate parameterized items
- Rapid and informative feedback to teachers and students
- Engaging—game-like, technology-infused, *virtual manipulatives*
- Supports both *sequestered assessment* AND *student-student interactions* around practice and exploration
- Flexible, rich representations / *reports* of student results: *feedback* to teachers *and* students (under development)
- Data systems support both formative assessment and analytic analysis
- Leverage social networking features
Prototyping a Diagnostic Assessment System

Database: Items, Sets of Items, Measures, Interventions

Diagnostics | Reports | Interventions

IDAS

Empirical Validation

Common Core Standards & Learning Trajectories

Cloud Computing

Collaboration and Artifact Sharing

Teacher/Leader Professional Development & Support

Student Device

Teacher/School Management and Monitoring System

Student Device

Student Device
Components of LPPSync

- Diagnostic Assessments
  - Demo
    - Sequenced Assessments
      - Reports on Completion
  - Sequenced Assessments
- Practice Zone
  - Immediate Machine Feedback
- Targeted Interventions
  - Curricular Pieces
  - Collaboration and Artifact Sharing

Independent Work
Collaborative Work
IGE Features

• Designed to address different proficiency levels
• Parameterized to produce different task classes
• A sampling of items is created: in each diagnostic assessment, students attempt 6 items of varying difficulty.
• Responses scored based on rubric of outcomes
• Rubrics also used to provide feedback in Practice Mode (eventually to guide development of interventions)
## From LT to LPPSync Packets

<table>
<thead>
<tr>
<th>EqPart Proficiency Levels</th>
<th>Packet #s</th>
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<tbody>
<tr>
<td>16 - Generalization</td>
<td>P7</td>
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<td>15 - Distribution</td>
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<td>14 - Covariation</td>
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<tr>
<td>13 – Composition of Splits (MW)</td>
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<tr>
<td>12 – Multiple Wholes</td>
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<td>11 - Continuity</td>
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<td>10 - Equality</td>
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<td>9 - Redistribution</td>
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<td>8 – Quantitative Compensation</td>
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<td>7 – Composition of Splits (SW)</td>
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<tr>
<td>6 – Qualitative Compensation</td>
<td>P7</td>
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<td>5 - Reassembly</td>
<td>P1, P2, P3, P4, P7</td>
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<td>4 – Naming</td>
<td>P1, P2, P3, P4, P7</td>
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<td>3 - Justification</td>
<td>P1, P2, P3, P4, P5, P7</td>
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<tr>
<td>2 – Wholes</td>
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<tr>
<td>1 - Collections</td>
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</table>
A Design Study on equipartitioning

• 12 Students, grades 1-4: 1 first grader (repeater), 1 rising second grader, 5 rising third graders and 5 rising fourth graders

• Two-week summer program: 2 hours per day

• Working through curricular packets and diagnostic assessments using iPads on collections, single wholes, reallocation, compensation and composition of splits

• Students tended to have difficulty in school
Research Question

In what ways can an IDAS support the effective instructional practices designed to enhance student learning (defined as progress along the equipartitioning learning trajectory,) using the selected curricular materials, in the context of a design study?
“Design experiments create the conditions for developing theories yet must place these theories in harm’s way. Thus, design experiments always have two faces: prospective and reflective. These two faces are familiar to all empirical scientists, but the forms they take in design experiments are somewhat specialized.

On the prospective side, designs are implemented with a hypothesized learning process and the means of supporting it in mind in order to expose the details of that process to scrutiny.

An equally important objective is to foster the emergence of other potential pathways for learning and development by capitalizing on contingencies that arise as the design unfolds.”

(Cobb et al., 2003, p. 10)
Testing Humble Theories

- Children’s abilities to carry out and reason about equipartitioning become stronger and more flexible as they learn to apply the three equipartitioning criteria of having the correct number of parts, exhausting the whole, and having the same size parts.
SHARING A RECTANGLE FOR FOUR
In humble theory example, the IDAS information could be understood as
a) encouraging encounter with and discussion of particular misconceptions,
b) supporting the personalization of instructor response for individual students
c) leading to recognition of the need to revise the reporting form to show the students’ submissions, and
d) introducing a rich context that gave rise to reasons for clarifying and embedding the ideas in discourse.

The discourse analysis in turn led to suggested revisions in the design of the IDAS interface and behavior. IDAS influence was mediated by the structure of the classroom and forms of interaction.
Conclusions

• Based on the design study and the conjectures with which the study began, one can examine these elements and ask how one’s understanding of an IDAS, and how it works in the context of this type of learning ecology, has changed. It is clearer now why viewing the IDAS as simply a value-added feature is insufficient.
• Implications for redesigning the IDAS
• Promise in using equipartitioning as foundation for division, multiplication, and rational number.
• The diagnostics are sobering, suggesting that regular teachers may be overly optimistic.