The Promise of Scaffolded Math Curriculum for Middle-School English Learners: Project MELD

Diane August, Ph.D.  Chris Barr, Ph.D.
American Institutes for Research  Rice University
Project MELD Team

**AIR Team**
- Diane August: Principal Investigator
- Ashley Simpson Baird: Project Director, English Learner Lead
- Alexandra Marken: Research Associate
- Tad Johnston: Mathematics Lead
- Kirk Walters: Senior Advisor

**Rice University**
- Chris Barr: Methodologist

**Rio Grande Valley Language and Learning Center**
- Elsa Cardenas Hagan: On-site Coordinator
- Benny Hernandez: On-site Research Associate
LearnZillion Team

- Posie Wood
- Jodi Rothstein
- Eric Westendorf
- Beth McHugh
- Ian Lotinsky

Base Math Curriculum used for MELD is adapted from LearnZillion
Project MELD Overview
What is Project MELD?

- IES-funded, five-year study to enhance sixth-grade, Spanish-speaking ELs’ math knowledge and academic language associated with math.

- Research questions:
  - *To what extent can the intervention be implemented successfully? What programmatic changes and enhancements are needed to improve the intervention?*
  - *How does Project MELD affect students’ math learning and development of math-related academic language?*
Few experimental studies on literacy and content-area instruction in middle grades (Baker et al., 2014; National Academy of Sciences, Engineering and Math, 2017).

Student learning is greater when

- academic vocabulary is taught intensively across several days;
- oral and written English language is integrated with content;
- there are regular structured opportunities to develop written language skills; and
- small-group instructional interventions are provided to students struggling in areas of literacy and English language development.
What is the intervention?

- **Materials**
  - LearnZillion (LZ) curriculum developed by exemplary teachers

- **Professional Development**

- **Base Math Curriculum**
What is the intervention?

Materials

Professional Development

Base Math Curriculum

One-day training prior to each unit of regular coaching
What is the intervention?

- Materials
- Professional Development
- Base Math Curriculum
Materials

- **Teacher Materials**
  - Teacher presentation slides
    - Brief teaching notes on each slide
  - Teacher guide
    - Slide by slide teaching notes
    - Answer keys

- **Student Materials**
  - Lesson and unit glossaries
  - Slide by slide notes and activities (e.g., scaffolded problems)
  - In class practice
  - Additional practice
Project MELD Development Timeline

2014
- Initial Development: MELD 1.0

2015
- MELD 1.0 Pilot Testing + Data Collection
- Revisions: MELD 2.0

2016
- MELD 2.0 Pilot Testing + Data Collection
- Revisions: MELD 3.0

2017
- MELD 3.0 Pilot Study + Data Collection
Curricular Modification #1: Use Research-based Scaffolds and Strategies
Integrate Language with Content

- Strategically use instructional tools—short videos, visuals, graphic organizers—to anchor instruction and help students make sense of content.
- Teach content-specific academic vocabulary as well as general vocabulary that supports it.
- Provide daily opportunities for students to talk about content in pairs and small groups.
- Provide writing opportunities to extend student learning and understanding of content material.
Scaffold Math Content

- Student glossaries
- Additional illustrations
- Graphic organizers
- Partner activities
- Response frames
- Worked examples
- Homework focused on academic language
- Home language support
<table>
<thead>
<tr>
<th>Card number</th>
<th>Repeat the word</th>
<th>Write the word!</th>
<th>Listen to the definition</th>
<th>Listen to the example</th>
<th>Think-Pair-Share</th>
</tr>
</thead>
</table>
| 5           | product        |                 | the result when two or more numbers are multiplied together | $3 \times 2 = 6$  
6 is the product of 3 and 2. | What are the products in the following number statements?  
1. $2 \times 3 = 6$  
The product is _______.  
2. $2 \times 2 = 4$  
The product is _______.  
3. $4 \times 5 = 20$  
The product is _______. |
|             | producto       |                 | el resultado cuando dos o más números se multiplican juntos |                     |                 |
| 6           | remainder      |                 | the amount left over after solving a division problem | $5 \div 2 = 4, \text{ R}1$  
5 divided by 2 is 4 with a remainder of 1. | What is the remainder in the following problem?  
$7 \div 2 =$ |
|             | resto          |                 | la cantidad que queda después de la resolución de un problema de división |                     |                 |
| 21          | summary        |                 | a short statement that tells the important information. | At the end of every lesson is a “Lesson Summary” where you write important information for that lesson. | Look in your student guide to find a lesson summary. Show it to your partner. |
|             | resumen        |                 | una frase corta que da información importante. |                     |                 |
Graphic Organizers

At Jack’s birthday party, the ratio of chocolate cupcakes to vanilla is three to one. Write four ratios:

- chocolate to vanilla
- vanilla to chocolate
- chocolate to total
- vanilla to total

Write each ratio in three ways:
1. use the word to
2. use a colon
3. use a fraction

<table>
<thead>
<tr>
<th></th>
<th>chocolate to vanilla</th>
<th>vanilla to chocolate</th>
<th>chocolate to total</th>
<th>vanilla to total</th>
</tr>
</thead>
<tbody>
<tr>
<td>to</td>
<td></td>
<td></td>
<td>3 to 1</td>
<td></td>
</tr>
<tr>
<td>colon (:)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>fraction</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Partner Activities

- Pair ELs with limited proficiency in English with bilingual partners
- Student pairs learn five core skills to make their conversations more academic:
  - Elaborate and clarify
  - Support ideas with examples
  - Build on and/or challenge a partner’s idea
  - Paraphrase
  - Synthesize conversation points
Response Stems and Frames

- Question: When do we use a double number line?
  - Response Stem: We use a double number line when we ________________________________.

- Question: What do each of the number lines represent?
  - Response Frame: In this example, the top number line represents the number of _____ and the bottom number line represents the number of ______.
Worked Examples

In-class Practice
Grade 6, Unit 1, Lesson 1

Part 1 – Use the grids to show all row and column arrangements for the factors of a number.

Example: Find the factors of 6.

The rectangles show 3 rows of 2, 2 rows of 3, 1 row of 6, and 6 rows of 1 (don’t have to draw duplicates).

The factors of 6 are 1, 2, 3, 6.
Homework focused on academic language
Home language support

- Bilingual student guides
- Intentional partnering
- Teacher translation
Connect to students’ lives to build background knowledge
Use students’ L1s strategically
Use checks for understanding to assess students’ emerging content and language knowledge development
Facilitate academic discourse about content
Partner ELs and non-ELs to provide authentic opportunities for interaction
Support students in making written and oral reflections about content
Curricular Modification #2: Build Foundational Skills
Build Foundational Skills

- Teaching academic language and scaffolding content may be insufficient.
- Because of their prior educational environments, interrupted schooling, or lack of quality instruction, many middle grade ELs will also need to work on building foundational skills.
Build Foundational Skills

**Skills focused on:**
- Multiplication and division facts
- Comparing fractions
- Converting between mixed numbers and improper fractions
- Simplifying fractions
- Multiplying fractions
- Finding equivalent fractions
- Factors and multiples
- GCF and LCM
- Distributive property

**Materials:**
- Supplementary lessons
- Sprints
Finding factors

- We can also find factors by dividing by natural numbers.
- Let’s practice with factors of 12.
- If we divide 12 by natural numbers, we will get all of the factors of 12:
  - $12 \div 1 = 12$
  - $12 \div 2 = 6$
  - $12 \div 3 = 4$
  - $12 \div 4 = 3$
  - $12 \div 5 = 2.4$
  - $12 \div 6 = 2$
  - $12 \div 7 = 1.7$

Additional Practice
Booster 1
Práctica Adicional
Intensificador 1

Part 1
Instructions: Circle the natural numbers in each set of numbers.

Parte 1
Instrucciones: Circula los números naturales en cada conjunto de números.

<table>
<thead>
<tr>
<th>A</th>
<th>-6</th>
<th>8.2</th>
<th>3</th>
<th>½</th>
<th>0.75</th>
<th>0</th>
<th>$\frac{35}{5}$</th>
<th>10</th>
<th>99</th>
<th>11.7</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>7</td>
<td>6.3</td>
<td>5</td>
<td>-5</td>
<td>300</td>
<td>$\frac{16}{5}$</td>
<td>0.333…</td>
<td>1</td>
<td>0.1</td>
<td>-1</td>
</tr>
</tbody>
</table>
Sprints

Name ____________________________

Multiply

\[
\begin{array}{cccc}
2 \times 1 &=& 2 \times 2 &=& 2 \times 3 &=& 2 \times 4 &=& \\
2 \times 5 &=& 2 \times 1 &=& 2 \times 2 &=& 2 \times 1 &=& \\
2 \times 3 &=& 2 \times 1 &=& 2 \times 4 &=& 2 \times 1 &=& \\
2 \times 5 &=& 2 \times 1 &=& 2 \times 2 &=& 2 \times 3 &=& \\
2 \times 2 &=& 2 \times 4 &=& 2 \times 2 &=& 2 \times 5 &=& \\
2 \times 2 &=& 2 \times 1 &=& 2 \times 2 &=& 2 \times 3 &=& \\
1 \times 1 &=& 2 \times 3 &=& 2 \times 2 &=& 2 \times 3 &=& \\
2 \times 4 &=& 2 \times 3 &=& 2 \times 5 &=& 2 \times 3 &=& \\
2 \times 4 &=& 2 \times 1 &=& 2 \times 4 &=& 2 \times 2 &=& \\
2 \times 4 &=& 2 \times 3 &=& 2 \times 4 &=& 2 \times 5 &=& \\
2 \times 4 &=& 2 \times 5 &=& 2 \times 1 &=& 2 \times 5 &=& \\
2 \times 2 &=& 2 \times 5 &=& 2 \times 3 &=& 2 \times 5 &=& \\
\end{array}
\]
Curricular Modification #3: Develop Conceptual Knowledge Through Hands-on Activities
Many ELs may need additional time to develop their conceptual knowledge in mathematics.

Hands on activities facilitate conceptual development while not requiring a high level of academic language.

Example: Using egg cartons and beans to develop knowledge of equivalent ratios.
Equivalent ratios can be built using a pattern.

This ratio is 2 red to 3 black.
Equivalent ratios can be built using a pattern.

This ratio is equivalent to 2 red to 3 black.
If all the beans are counted it is 4 red to 6 black.
Equivalent ratios can be built using a pattern.

This ratio is equivalent to 2 red to 3 black. If all the beans are counted the ratio is 6 red to 9 black.
Equivalent ratios can be built using a pattern.

This ratio is equivalent to 2 red to 3 black. What is the ratio counting all the beans?
We can keep track with a ratio table.

<table>
<thead>
<tr>
<th></th>
<th>RED</th>
<th>BLACK</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>15</td>
</tr>
</tbody>
</table>
Pilot Study
Pilot Study: Context

- Five public middle schools in the Rio Grande Valley
- District students are 85% Latino
- District students are 15% EL
- District students are 77% economically disadvantaged
- A supplemental math class for sixth grade students who had not met math benchmarks by the end of fifth grade
  - Treatment condition: MELD intervention used as the additional math class
  - Control condition: District curriculum used as the additional math class
## Pilot Study: Sample

<table>
<thead>
<tr>
<th></th>
<th>Non-ELs</th>
<th>ELs</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall 2017 MELD students</td>
<td>44</td>
<td>48</td>
<td>92</td>
</tr>
<tr>
<td>Fall 2017 control students</td>
<td>21</td>
<td>8</td>
<td>29</td>
</tr>
<tr>
<td>Spring 2018 control students</td>
<td>66</td>
<td>42</td>
<td>108</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>131</td>
<td>98</td>
<td>229</td>
</tr>
</tbody>
</table>
Pilot Study: District Supplement vs. MELD Supplement

- **District Curriculum**
  - Content:
    - Fraction and decimal computation
    - Ratios
    - Percentages
  - Faster pacing
  - Singular methods for problem solving
  - No explicit focus on academic language development

- **MELD Supplement**
  - Content:
    - Fraction and decimal computation
    - Ratios
    - Percentages
  - Slower pacing
  - Multiple methods for problem solving
  - Focus on academic language development
Pilot Study: Measures

- **Treatment group:**
  - Math readiness
  - Math assessments
  - Vocabulary assessments
  - Academic language
  - Teacher pre- and post-surveys
  - Classroom observations
  - Teacher logs
  - Teacher debriefs

- **Control group:**
  - Math readiness
  - Math assessments
  - Vocabulary assessments
1. Jason has 160 pencils. He wants to give each friend the same number of pencils. Which table shows the relationship between $n$, the number of friends he shares with, and $p$, the number of pencils each person gets?

Jason tiene 160 lápices. Él quiere dar a cada amigo el mismo número de lápices. ¿Qué tabla muestra la relación entre $n$, el número de amigos con los que comparte, y $p$, el número de lápices que cada persona obtiene?

<table>
<thead>
<tr>
<th>Number of People, $n$</th>
<th>Number of Pencils, $p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>80</td>
</tr>
<tr>
<td>4</td>
<td>40</td>
</tr>
<tr>
<td>10</td>
<td>16</td>
</tr>
<tr>
<td>20</td>
<td>8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of People, $n$</th>
<th>Number of Pencils, $p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>b</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>150</td>
</tr>
<tr>
<td>20</td>
<td>140</td>
</tr>
<tr>
<td>30</td>
<td>130</td>
</tr>
<tr>
<td>40</td>
<td>120</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of People, $n$</th>
<th>Number of Pencils, $p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>c</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>320</td>
</tr>
<tr>
<td>4</td>
<td>640</td>
</tr>
<tr>
<td>10</td>
<td>1,600</td>
</tr>
<tr>
<td>20</td>
<td>3,200</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of People, $n$</th>
<th>Number of Pencils, $p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>d</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>16</td>
</tr>
<tr>
<td>20</td>
<td>14</td>
</tr>
<tr>
<td>30</td>
<td>12</td>
</tr>
<tr>
<td>40</td>
<td>10</td>
</tr>
</tbody>
</table>

- **relationship**
- **a connection**
- **una conexión**
Vocabulary Items

1. __________ means the answer to a subtraction problem.  
   Example: The ________ between 5 and 3 is 2.

2. __________ means having the same value. Example: 
   \[5 \times 3 = 1 \times 15\]

3. __________ means place or space  
   Example: The _____ of a triangle is the space inside of the triangle.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>area</td>
</tr>
<tr>
<td>B</td>
<td>Distributive Property</td>
</tr>
<tr>
<td>C</td>
<td>equivalent</td>
</tr>
<tr>
<td>D</td>
<td>difference</td>
</tr>
<tr>
<td>E</td>
<td>design</td>
</tr>
</tbody>
</table>
Pilot Study: Analytic Approach

- All models were fit using generalized linear mixed effects modeling.
- Data were modeled at the item level and a random intercept was fit for student and school.
- Item performance was predicted by wave (pre-post), treatment (MELD supplement versus district supplement); EL status, as well as the two-way and three-way interactions.
Pilot Study: Comparisons

- District supplement vs. MELD supplement
- No supplement vs. MELD supplement
ELs and English-proficient students who received MELD supplemental instruction had statistically significant and larger gains in math and vocabulary than their peers who received the district supplement.

ELs and English-proficient students who received supplemental instruction using the MELD curriculum had statistically significant and larger gains in math and vocabulary than ELs and English-proficient students who received no supplemental math.
Diane August
202-403-5949
daugust@air.org

1000 Thomas Jefferson Street NW
Washington, DC 20007-3835
202-403-5000
TTY: 877-334-3499
ELLCenter@air.org
www.air.org