Incorporating Language Into Early Math Instruction:
Using Research-Based, Developmentally-Appropriate Strategies and Activities

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Overview

- **Introduction** - why math, talk, and math talk matter
- **Teaching Strategies** - discussion and illustrative examples
- **Conclusion** - bringing it all together
Early Mathematics

- Early math skills are critical for later school achievement in both math and reading (Duncan, et al., 2007; Grissmer et al., 2010; Watts, et al., 2014)

- Children from lower SES homes and from ethnic and language minority backgrounds are at risk for lack of readiness in math and other domains (e.g., Denton & West, 2002)
Early Language

- The language adults use impacts children
  - Gap in number of words disadvantaged versus advantaged children hear (Hart & Risley, 1995)
  - Vocabulary gap by age 2 (Hart & Risley, 1995)
  - Not just number of words, but also quality of words parents use that matter (Hirsh-Pasek, NAEYC, 2014)
  - Rich vocabulary impacts reading achievement (Strickland & Riley-Ayers, 2006)
The Achievement Gap Emerges by Age Two

Mathematics and Language

- Math and language are inextricably connected (e.g., Whitin & Whitin 2003).

- Teaching math with attention to teachers’ and children’s math language can lead to gains in math and in language (Sarama, Lange, Clements, & Wolfe, 2012)

- Amount and diversity of math language teachers use improves children’s math learning (Klibanoff et al., 2006)

- Teachers can plan experiences that connect new mathematical terms or phrases to ideas children already know (Rubenstein & Thompson 2002).
The Problem

- High-quality math teaching is not common (Ginsburg et al., 2008)
- Math content in teacher math talk is limited (Rudd et al., 2008)
- Preschool teachers are not typically well-prepared to teach STEM (NRC, 2009) or DLLs (Espinosa, 2010; Freedson, 2010)
An Example From One Study

Table 3 Descriptive statistics of observed math-mediated language

<table>
<thead>
<tr>
<th>Math category</th>
<th>Frequency</th>
<th>Percentage</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>701</td>
<td>32</td>
<td>63.73</td>
<td>63.58</td>
</tr>
<tr>
<td>Spatial</td>
<td>885</td>
<td>41</td>
<td>80.45</td>
<td>30.44</td>
</tr>
<tr>
<td>Geometry</td>
<td>26</td>
<td>1.2</td>
<td>2.36</td>
<td>1.80</td>
</tr>
<tr>
<td>Measurement</td>
<td>428</td>
<td>20</td>
<td>38.91</td>
<td>14.57</td>
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<tr>
<td>Seriation</td>
<td>110</td>
<td>5</td>
<td>10.00</td>
<td>6.63</td>
</tr>
<tr>
<td>Operations</td>
<td>4</td>
<td>.1</td>
<td>.36</td>
<td>.67</td>
</tr>
<tr>
<td>Pattern</td>
<td>5</td>
<td>.3</td>
<td>.64</td>
<td>1.57</td>
</tr>
<tr>
<td>Display</td>
<td>2</td>
<td>.1</td>
<td>.18</td>
<td>.41</td>
</tr>
</tbody>
</table>

Source: Rudd, Lambert, Satterwhite, & Zaier (2008)
SciMath-DLL Model

- Workshops, PLCs, and in-class reflective coaching

- Encouraging development of STEM does not have to “take away” from literacy/language development
Teaching Strategies

- Discuss 4 strategies for incorporating more and higher-quality language into math instruction

- Illustrate using activities from SciMath-DLL work

- *Caveat - understanding how math and language develop is key, but not discussed here* (e.g., learning trajectories: Clements & Sarama, 2014)
Strategy #1: Talk to Kids Intentionally About Math

- Start math number games by saying, “The numbers go from smallest here (1) to largest there (10).”

  1 2 3 4 5 6 7 8 9 10

- Math games
  - Prior work (Ramani, Siegler, & Hitti, 2012; Laski & Siegler, 2014; Laski & Collins, in preparation)
  - Our work (Lange, Brenneman, & El-Moslimany, in preparation)
Example Activity: *Math Number Games*

- **Try it!**
  - Look at instructions
  - Play game

- **Think about**
  - How can teacher language enhance game play?
  - How could children’s language skill impact game play?

*Source:* Adapted from Ramani, Siegler, & Hitti (2012)
Strategy #2: Encourage Children to Explain Their Mathematical Reasoning

- Ask questions such as, “How do you know?”

- Why?
  - Leads to explaining, which improves learning (Rittle-Johnson, Saylor, & Swygart, 2008)
  - Encourages children to think about their thinking (Greenes, 1999)
  - Allows children to hear peers describe their thinking
  - Provides teachers opportunity for formative assessment
Example Activity: *Roll and Build*

- **Watch Video**

- **Think about**
  - What mathematical language could teachers use, and elicit from children, while playing this game?
  - How might the multiple representations of numbers contribute to children’s understanding and learning?
Strategy #3: Use Accurate Math Explanations and Vocabulary with Children

- Many adults say, “A rectangle has two long sides and two short sides?”

- Which of these is a square? Rectangle?

- How do you know?
The Case of the “Special Rectangle”

- Consider the definition: *a rectangle is a 2D shape with four straight sides, all connected at four corners (points), all right angles.*

- Does a rectangle *necessarily* have “two long sides and two short sides”? Why might it be a problem to teach children this definition?
Accurate Vocabulary Can Be Age-Appropriate

- **Vocabulary:**
  - *rhombus* (diamond)
  - Spanish: *el rombo*
Teach Shapes by Their Properties

- A square is a rhombus, but a rhombus is **not necessarily** a square.

- How can children learn this?
  - “Is it or not?” game - Is this a square? Why or why not?

*Source: Adapted from Clements & Sarama (2014)*
Example Activity: *Shapes with a Line*

- **Watch Video**

- **Try it!**
  - Look at instructions
  - Do activity

- **Think about**
  - How can teacher language encourage learning about shape properties?
  - How does this activity allow children to practice and talk about correct and incorrect notions of shape?

*Source: Adapted from Cathy Weisman Topal (2005)*
Strategy #4: Adapt Questioning for Children at Different Levels of Language Proficiency

- Asking children, “Where is a square?” versus “How do you know it is a square?”

- When are simple, closed-ended questions or commands okay (or even preferred)?
## DLLs: Tiered Levels of Questions

<table>
<thead>
<tr>
<th>Language Level</th>
<th>Example Questions</th>
<th>Types of Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Home Use/Non-Verbal</strong></td>
<td>Show me…</td>
<td>-Known answer</td>
</tr>
<tr>
<td></td>
<td>Point to…</td>
<td>-Closed</td>
</tr>
<tr>
<td></td>
<td>Where is?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Who has?</td>
<td></td>
</tr>
<tr>
<td><strong>Telegraphic/Formulaic</strong></td>
<td>Yes/No questions</td>
<td>-Known answer</td>
</tr>
<tr>
<td></td>
<td>Either/Or questions</td>
<td>-Closed</td>
</tr>
<tr>
<td><strong>Productive</strong></td>
<td>Why?</td>
<td>-Thought-provoking</td>
</tr>
<tr>
<td></td>
<td>How?</td>
<td>-Open-ended</td>
</tr>
<tr>
<td></td>
<td>Explain</td>
<td></td>
</tr>
<tr>
<td><strong>More Advanced Productive</strong></td>
<td>What would happen if?</td>
<td>-Thought-provoking</td>
</tr>
<tr>
<td></td>
<td>Why do you think?</td>
<td>-Open-ended</td>
</tr>
<tr>
<td></td>
<td>Retell…</td>
<td>-Prediction</td>
</tr>
</tbody>
</table>

*Sources: Krashen & Terrell (1983); Tabors (2008)*
Remember…

- Giving children time to respond matters
  
  (Cohrssen, Church, & Tayler, 2014; Mauigoa-Tekene, 2006)
Example Activity: *Find a Shape!*

- **Try it!**
  - Look at instructions
  - Do activity

- **Think about**
  - How could you adapt your questioning and language to engage children at different levels of English-language proficiency?
The Four Strategies Were...

- **Strategy #1:** Talk to Kids Intentionally About Math
- **Strategy #2:** Encourage Children to Explain Their Mathematical Reasoning
- **Strategy #3:** Use Accurate Math Explanations and Vocabulary with Children
- **Strategy #4:** Adapt Questioning for Children at Different Levels of Language Proficiency
Results - Preliminary Findings

- Teacher and coach report, observational notes
  - **Strategy #1**: Less directive teacher language
  - **Strategy #2**: More questioning
  - **Strategy #3**: Increased teacher use of math and science vocabulary
    - Improved student vocabulary and language skills (noted by many)
  - **Strategy #4**: Greater use of science and math vocabulary and in English language by DLLs, more wait time for children to respond
Results - Example Participant Quotes

- “Students are excited about building their vocabulary! They love demonstrating new concepts and what they have learned…”

- “This child comes from a home where English is never spoken and yet he spent over half an hour engaged in play activities that promoted a conversation in English that was rich not only in science vocabulary but also in the way he uses question words, grammar, and sentence structure in his play.”

- “Students are answering in their home language and or better English language. Students are making connections with whole sentences made.”
To Conclude

- Teachers can change their practice to use more of the math (and science) language that improves learning for children.

- Our next project will evaluate program impacts on teachers and children experimentally.
THANK YOU!

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More Information

- Please email us at alange@nieer.org for copies of the lesson plans for the Example Activities.

- In order to make copies of the lesson plans to share with colleagues, please email us your specific request.
References (p.1 of 2)

- Hirsh-Pasek, K. (2014). It’s a Talk-Back! Engaging the whole nation in a giant conversation. Paper presented at the NAEYC annual meeting, November 5-8, Dallas, TX.
References (p.2 of 2)