Mathematical Problem Solving and Discourse Development Among Spanish-Speaking Primary Grade Students

Mary Marshall, University of New Mexico
Dr. Sandra Musanti, University of New Mexico
Dr. Sylvia Celedón-Pattichis, University of New Mexico

CEMELA Research Symposium
January 18-20, 2008
University of California at Santa Cruz

National Science Foundation Award No. ESI-0424983

CEMELA (Center for the Mathematics Education of Latinos/as)
Mathematics and Language

- Students organize and consolidate their mathematical thinking through communication (NCTM, 2000)
  - Formal mathematics is a social construction (Van Oers, 2001)
  - Language is a psychological and social tool for learning
- It is important to explore how language mediates the appropriation and construction of formal conceptual knowledge within Latino populations.
Research Questions

What is the nature of Spanish-speaking primary grade students’ problem solving and mathematical discourse development?

- What strategies do they use to solve context-embedded word problems?
- How do they communicate their thinking verbally in their native language?
Participants and Study Site
2006-2007

- Eight students (6 girls and 2 boys)
  - Part of the 2005-2006 CEMELA kindergarten study on CGI problem solving (Turner et al., in press)
- Two bilingual 1st grade teachers
  - Native Spanish speakers
  - Mathematics instruction in Spanish
- Urban elementary school
  - Promotes bilingualism and biliteracy
  - 86% Latino population
  - 99% free or reduced meals
  - Large Mexican immigrant population
Theoretical Framework

- Problem solving is fundamental to mathematical learning (Carpenter, Fennema, Franke, Levi & Empson, 1999)
- Knowledge is socially constructed (Vygotsky, 1986; Forman, McCormick & Donato, 1998)
- Language development supports and is supported by cognitive development (John-Steiner & Mahn, 1996)
Cognitively Guided Instruction (CGI)

- Framework for understanding children’s thinking
- Context-embedded word problems
- Emphasis on explaining and justifying

Problem example:

“You had some pencils. Then you gave 6 pencils to your friend. Now you have 13 pencils. How many pencils did you have to start with?”
Problem Solving Strategies

Problem-solving strategies tell us a great deal about students’ mathematical thinking and sense of number (Carpenter et al., 1994)

- Direct modeling
- Counting and recalled facts
- Derived strategies
Method and Data Collection for 1st Grade

- Weekly in-class support of teachers to design CGI problem solving lessons
- In-class observations and collection of student representations
- Individual student problem-solving interviews in November 2006 and May 2007
Methodology

- Mixed methodology from a primarily qualitative perspective
  - Qualitative approach to analyze students’ developing mathematical understanding and discourse
  - Quantitative breakdown of students’ problem solving strategies and correct solutions
Findings - 1st Grade

Students successfully solving all problem types (7 students evaluated)

Comparison of Advanced Strategies to Correct Answers

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Brisa</td>
<td>0%</td>
<td>92%</td>
<td>33%</td>
<td>89%</td>
</tr>
<tr>
<td>Ana</td>
<td>0%</td>
<td>86%</td>
<td>22%</td>
<td>96%</td>
</tr>
<tr>
<td>Yolanda</td>
<td>71%</td>
<td>71%</td>
<td>75%</td>
<td>92%</td>
</tr>
<tr>
<td>Omar</td>
<td>64%</td>
<td>86%</td>
<td>81%</td>
<td>86%</td>
</tr>
<tr>
<td>Jenna</td>
<td>0%</td>
<td>63%</td>
<td>36%</td>
<td>86%</td>
</tr>
<tr>
<td>Gina</td>
<td>36%</td>
<td>93%</td>
<td>43%</td>
<td>100%</td>
</tr>
<tr>
<td>Gerardo</td>
<td>31%</td>
<td>81%</td>
<td>44%</td>
<td>90%</td>
</tr>
<tr>
<td>Averages</td>
<td>29%</td>
<td>82%</td>
<td>48%</td>
<td>91%</td>
</tr>
</tbody>
</table>
# Findings - 1st Grade

Students move from direct modeling to more advanced strategies

Use of Advanced Strategies

<table>
<thead>
<tr>
<th>Student</th>
<th>November 2006</th>
<th>May 2007</th>
<th>Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brisa</td>
<td>0%</td>
<td>33%</td>
<td>33%</td>
</tr>
<tr>
<td>Ana</td>
<td>0%</td>
<td>22%</td>
<td>22%</td>
</tr>
<tr>
<td>Yolanda</td>
<td>71%</td>
<td>75%</td>
<td>4%</td>
</tr>
<tr>
<td>Omar</td>
<td>64%</td>
<td>81%</td>
<td>17%</td>
</tr>
<tr>
<td>Jenna</td>
<td>0%</td>
<td>36%</td>
<td>36%</td>
</tr>
<tr>
<td>Gina</td>
<td>36%</td>
<td>43%</td>
<td>7%</td>
</tr>
<tr>
<td>Gerardo</td>
<td>31%</td>
<td>44%</td>
<td>13%</td>
</tr>
</tbody>
</table>
Students are developing the language they need to describe and organize their thinking

Problem: 7 bags with 10 marbles in each bag plus 6 single marbles. How many in all?

- Brisa: Porque puse diez...había...Ashley tenía 7 bolsitas de canicas, en cada bolsita tenía 10. Y conté de 10 en 10 hasta 70 y habían 6 sueltas y le conté 70 hasta 76.
- Because I put 10...there were...Ashley had 7 bags of marbles, in each bag she had 10. And I counted by 10s up to 70 and there were 6 singles and I counted from 70 to 76.
Implications

- Low SES Spanish-speaking students have the linguistic and psychological tools they need to successfully solve complex problems.
- Assessment that focuses only on the correct answer misses important information about student thinking and language.
- These students are ready for challenging problems to develop a deeper sense of number.
Dissertation Research

- Longitudinal study continues in a second grade bilingual classroom.
  - Design experiment to develop sociomathematical norms (Cobb, 2000; Gravemeijer, 2004)
  - Lessons to focus on representational tools, specifically diagrams of problems
  - Attention to Spanish linguistic structures in student explanations

Contact: Mary Marshall, mmarshal@unm.edu