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Early Elementary Students' Representation Choice and Use during Word Problem Solving

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When given the choice, how do early elementary students choose to solve problems and show their reasoning?

What can it reveal about their understanding of not just representation but numerical symbols







Goals



- Assessing students' choice of representational tools and means of communication during their solutions to CGI-style word problems and during their explanations
- Identifying methods to assess early elementary mathematics students' problem solving skills and conceptual understanding







Background



- An assumption embedded within common mathematics education practices is that students should be aided to move from concrete representations of quantities to more abstract (NCTM, 2000), especially in the early elementary years (Ball, 1992).
- Many representational tools and symbols are introduced and available to these novice mathematics learners, but much is yet to be understood about how they use these



symbols.









- Offering a choice of materials to express their ideas creates the opportunity for students to use any one of the available tools (or none) or to use multiple representations to answer.
- The open-ended story problems used, modeled after the Cognitively Guided Instruction program (Carpenter et al., 1999) do not specify a solution strategy, facilitating examination of children's strategic thinking (e.g., Verschaffel & Decorte, 1993).







Procedure



- Students in grades K, 1, and 2 participated in 3 sessions: the first two approximately one month apart in Spring, with a delayed follow-up session in late autumn.
 - Sessions were 1 on 1 with and videotaped.
- Each student answered 6 grade-level word problems (Carpenter et al., 1999) per session
 - A variety of CGI problem structures
- The researcher read each problem two times and repeated it as many times as requested.
 - After time to solve the problem, the researcher asked, "Can you tell me how you figured out your answer?".







Participants



- Participants all attended the same suburban Midwestern primary school, which participated in the MCP during the students' participation.
- Participants:
 - 20 kindergartners
 - 22 first graders
 - 30 second graders
 - The results reported today are on a subset of the 1^{st} and 2^{nd} grade students







Materials



- The interviewer informed the students that could use any of the provided materials and any methods of their choice and they didn't have to use any unless they wanted to. The materials provided by the researcher included:
 - A 100 chart (10 x 10)
 - Pencil, markers and paper
 - Base-10 blocks
 - Unifix cubes
 - A number line from 0 through 25
 - Multi-colored wooden cubes







Example Problems



- 1st grade: David has 3 bags of candies. There are 4 candies in each bag. How many candies does David have altogether?
- 2nd grade: Ms. Baker's class has 29 students. 15 of the students are boys. How many are girls?







Procedures:



Coding Representation Use

• *Coding*. The use of representations was coded from video, noting the use or creation of any representation during problem solving and subsequent explanation, including tool use, drawing, writing and gesture.







Results: Solutions and Use of Materials



- As shown on the following graph, most students used more than one type of representation during a session.
 - Students, especially those in the 2nd grade cohort, used a variety of representations rather than favoring one representational type.



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Figure 1: 1st & 2nd Grade Students' Use of Representational Tools







representational tools?

- Examining the students' use of gestures, blocks, student-created drawings/writing, and preprinted writing
 - *Most* students used a symbolic representation on *every* problem.
- *Every* student used a representation on *at least one* of the problems in each session.
 - Students in both grades decreased their use of gesture over the sessions and significantly increased their use of drawings or written equations.
 - 2nd-grade participants significantly increased their use of pre-printed materials, particularly the 100 chart





Figure 2: How often did students use more than 1 type of **NEWARK** representational tool *on a single problem*?





Figure 2: Multiple representations NEWARK



- within a problem
 Significantly more 2nd graders used multiple representations on any single problem than 1st graders.
 - A subset of students from each grade consistently used multiple forms across all 6 problems for a session
- Many other students used multiple representations only occasionally, raising the question of whether their use of multiple representations was situational (e.g., induced by a struggle on a particular problem), rather than a preference for the student.







Results & Discussion



- Individual differences:
 - Students' use of representations differed in their type and frequency and changed from session to session, typically in favor of creating drawings or written number solutions and referring to manipulatives less.
- Even given successful use of manipulatives for problem solving, the mapping to more abstract representations, such as writing an equation, cannot be assumed to be an easy or transparent processing Program a young learner.





Implications



- Designing learning experiences that support the development of students' understanding of multiple forms of representation and the connections between them
 - "Connections must be established for both numerical symbols and operation symbols."
 - Young learners' mappings or translations between representations must be supported. (Uttal, Scudder, & DeLoache, 1997)
- Planning assessment experiences that incorporate the use of multiple representations for early elementary students







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