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CHANGING MINDS

Insights Into the Mathematical Thinking of Students in Grades 2-4

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Abstract

This poster illustrates how information collected during student think-alouds can inform the assessment development process by providing concrete examples of students' misconceptions and valuable insights regarding the clarity of mathematics problems. For this study we collected think-aloud data from 30 students in Grades 2-4 as they solved 10 multiple-choice mathematics items. We present illustrative examples collected during the think-alouds and discuss how this information was used to inform future item development. We also provide preliminary evidence that having students think-aloud while solving math problems is positively related to their sense of mathematics self-efficacy.

Background

Verbal protocols, or student think-alouds, can provide information about the cognitive processes students engage in while completing a task (Ericsson & Simon, 1993) and students' understanding (or misunderstanding) of content (Leighton, 2004) with an ultimate goal of seeing first-hand the *process* of task completion, rather than just the final product (i.e., selection of a response). A review of the literature reveals the frequent collection of two types of think-aloud data:

- **Concurrent Think-Alouds:** Students are asked to think aloud *while* they complete a task, or talk about what they are doing as they are doing it. Students are **not** asked to explain what they are doing or why they are doing it.
- **Retrospective Think-Alouds:** Students are asked to describe their cognitive processes *after* they solved the problem. This provides students with an opportunity to describe any metacognitive processes they engaged in and is intended to verify that the content of the concurrent think-aloud is accurate. Retrospective think-alouds are currently designed to include specific questions about processes or perceptions that you want to learn more about.

Self efficacy in education refers to the beliefs students hold about their capability to accomplish tasks required for learning (Joet, Usher, & Bressoux, 2011). Perceptions of self-efficacy formed in elementary school are believed to be cornerstone on which subsequent beliefs about one's self efficacy are structured (Bandura, 1997). Recent research (Adelson & McCoach, 2011; Hackett & Betz, 1989; Joet et al., 2011) reveals positive moderate relations between mathematics self-efficacy and mathematics performance for students in Grades 3 – college.

Purpose

The purpose of this study is twofold:

1. To describe how student-think aloud data can be used to inform the assessment development process
2. To explore the relation between the opportunity to think-aloud while solving math problems and mathematics self-efficacy

Method

Participants

Participants in this study included 30 students in Grades 2-4 (10 from each grade) of varying mathematics ability whose classroom teachers volunteered to participate in the study. Students ages ranged from 7 – 10 years, 53% of students were female, and 80% of students were white.

Procedures

- Prior to collecting think-aloud data or having students respond to the 10 multiple-choice items, students completed the Math & Me Survey (Adelson, 2006).
- Interviews to collect think-aloud data were conducted 1:1 with an interviewer, observed by a field-observer, and audio-recorded. The interviewer explained the task to students, modeled how to think-aloud, and then had students practice thinking aloud while solving one problem.
- Then, for each of the 10 multiple-choice items, the following steps took place: (1) students saw the problem and predicted their likelihood of selecting the correct response, (2) students solved the problem while thinking aloud (concurrent think-aloud), (3) students rated their confidence in the correctness of their response and their perceived difficulty of the item, and (4) students responded to a series of follow-up, retrospective think-aloud questions.
- After solving all 10 items, students completed the Math & Me Survey a second time.

Illustrative Examples from Verbal Protocols

Grade 2

Question 2 of 10

Nancy invited 12 friends to her party on Tuesday.

On Wednesday, she invited 5 more.

On Thursday, she found out that 2 friends could not come.

Which number sentence shows the total number of friends invited to Nancy's party?

- 12 – 5 = □
- 12 + 5 – 2 = □
- 12 + 5 = □
- 12 + 5 + 2 = □

Submit

# Who Selected Correct Response	0
# Who Selected Distractor B	9
Average Response Time	1:25

Students' rationale for their answer choice:

" [I knew B was the correct response] because it has all of the numbers that is on the question."

"[The problem is asking] what is like the – like what total of it is how many friends is gonna come?"

90% of students appear to have selected the incorrect response based on an understanding or expectation they were being asked to figure out the number of friends that were coming to the party.

For this item, the think-alouds verified that students **did not** understand they were being asked to write an equation to represent the problem. Based on the average response time and student responses to level of difficulty, our item construct was verified.

DECISION: Clarify the question stem.

Grade 4

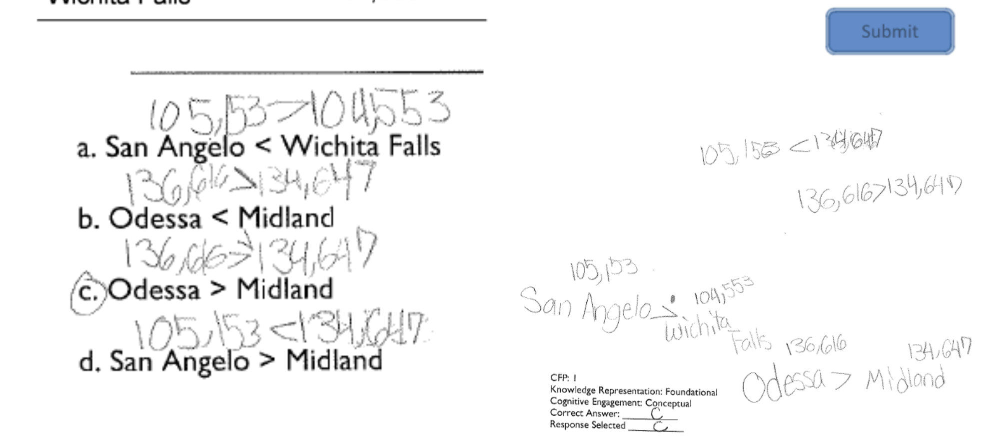
Question 1 of 10

Which expression correctly describes the populations?

City	Population
Midland	134,647
Odessa	136,616
San Angelo	105,153
Wichita Falls	104,553

- San Angelo < Wichita Falls
- Odessa < Midland
- Odessa > Midland
- San Angelo > Midland

Submit



# Who Selected the Correct Response	7
Average Response Time	**4:32**
Minimum Response Time	3:00
Maximum Response Time	**7:00**

What is this problem asking you to do?

"Eaten or protected"

Why didn't you select Response D?

"Because its pointing at this one, saying that this one would get eaten but this one's supposed to get eaten, not that one"

For this item, students' problem-solving processes showed they were spending a significant amount of time rewriting the problem to make the populations of the cities easier to compare. Multiple students also said they found it challenging to read some of the city names in the problem.

SUGGESTIONS FOR REVISION:

Consider using names/items for comparison that are easily decodable and/or familiar for students

Depending on the target level of difficulty, consider including 3 options for comparison instead of 4

How Can Think-Alouds Inform Assessment Development?

By providing information about…

- W*hy* students selected a particular response – what information in a particular response option is "attractive" to students? (see Grade 2 example)
- *How* students are solving a problem that may be introducing unnecessary complexity and increasing the possibility for error (see Grade 4 example)
- Whether students are using the math-based skills and strategies taught during instruction to solve a problem or if they are relying on a more general "test-taking" strategy (e.g., process of elimination)
- Students' understanding of the language used in an item and whether that understanding influences their ability to select the correct response (e.g., Do they know what the problem is asking them to do?)

Self-Efficacy Results

Here we compare the change in the level of agreement students had with the 18 math-related statements on the Math & Me self-efficacy survey from pretest (prior to solving the problems and thinking aloud) to posttest (after solving and thinking aloud).

- Number of respondents: 28 – 29 per item (Grades 2-4)
- Scale: Strongly Disagree, Disagree, Neither Disagree or Agree, Agree, Strongly Agree

Item	% of students whose responses were more negative at post-test	% of students whose responses were the same at post-test	% of students whose responses were more positive at posttest
1. I am good at math	25.00%	46.43%	28.57%
2. I love math.	14.29%	53.57%	32.14%
3. I understand math.	24.14%	41.38%	34.48%
4. Math is boring.	6.90%	44.83%	48.26%
5. I can solve difficult math problems.	11.54%	61.54%	26.92%
6. I enjoy doing math problems.	17.86%	42.86%	39.29%
7. Math is very hard for me.	27.59%	34.48%	37.93%
8. I do math problems on my own "just for fun"	20.69%	37.93%	41.38%
9. Math is confusing to me.	35.71%	35.71%	28.57%
10. Math is fun.	10.34%	48.28%	41.38%
11. I look forward to learning new math.	21.43%	25.00%	53.57%
12. Math comes easily to me.	17.24%	51.72%	31.03%
13.I hate math.	6.90%	58.62%	34.48%
14. I enjoy playing math games.	24.14%	44.83%	31.03%
15. I can tell if my answers in math make sense.	10.34%	51.72%	37.93%
16. I enjoy studying math.	13.79%	58.62%	27.59%
17. Doing math is easy for me.	13.79%	41.38%	44.83%
18. Solving math problems is fun.	10.34%	44.83%	44.83%

- Responses for the majority of students in Grades 2-4 were more positive after solving the problems and doing the think-aloud task with the interviewer.
- Between approximately 30% and 40% of students indicated they did not find math as boring, did not perceive it as hard or confusing, and did not agree as much with the statement "I hate math" after doing the think-aloud task with the interviewer.
- On average, Grade 2 students were more likely to change their ratings to indicate more positive perceptions of mathematics self-efficacy than students in Grades 3 and 4. 51.4% of Grade 2 students' responses were more positive at post-test than at pretest, compared to 45.57% of Grade 3 student's responses and only 16% of Grade 4 students' responses.
- The majority of students' responses in Grade 4 (61%) did not change from pretest to posttest, indicating their mathematics self-efficacy may be more firmly established.

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Questions? For further information about our research, please contact Research in Mathematics Education at Southern Methodist University (rme@smu.edu).