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 relationship between the opportunity to think aloud while solving math problems and mathematics self-efficacy.

**Method**
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 reported 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.

**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, Neutral Disagree or Agree, Agree, Strongly Agree

### 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 correctness 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 ability to accomplish metacognitive processes. Researchers (Adelson, 2011; Breault, 2012; Breault, 2013) have hypothesized that students’ self-efficacy is related to their performance. Students with higher self-efficacy are more likely to engage in metacognitive processes and have higher achievement than students with lower self-efficacy. The results of this study suggest that having student think alouds while solving math problems can help foster students’ self-efficacy.

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

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 construction was verified.

**DECISION:** Clarify the question stem.

**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?

A. 12 + 5 + 2 = ?
B. 12 + 5 = ?
C. 12 – 2 = ?
D. 12 – 2 + 5 = ?

**# Who Selected Correct Response:** 7

**Average Response Time:** 1.25

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 decodeable and/or familiar for students.
- Dependent on the target level of difficulty, consider including 3 options for comparison instead of 4.

### Grade 4
**Question 1 of 10**

Which expression correctly describes the populations?

<table>
<thead>
<tr>
<th>City</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>San Antonio</td>
<td>1,247,047</td>
</tr>
<tr>
<td>Odessa</td>
<td>138,718</td>
</tr>
<tr>
<td>San Angelo</td>
<td>96,105</td>
</tr>
<tr>
<td>Waco Falls</td>
<td>104,983</td>
</tr>
</tbody>
</table>

**# Who Selected the Correct Response:** 7

**Average Response Time:** 3:00

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 decodeable and/or familiar for students.
- Dependent 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...**
- Why 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 first-hand knowledge 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).

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