Verbal Imprecision in Mathematical Explanations as an Indicator of Learning

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Current Focus

Are disfluencies in self-explanation responses indicators of learning?

Verbal Disfluency & Learning

As students learn a new domain, they must construct a schema or mental model of the domain and problem solving procedures. These must be iteratively revised as learning occurs.

- An impasse occurs when the step the learner believes should be executed next cannot be preformed (Van Lehn, 1988)
- Speakers use *uh* and *um* to implicate when they are searching or deciding about what to utter next (Clark & Fox Tree, 2002)
- Learning is thought to occur at these impasses (Van Lehn, 1988)

Method

- **DOMAIN:** Mathematical equivalence is the principle that two sides of an equation represent the same value
- Foundational for algebra (Falkner, Levi, & Carpenter, 1999)

3 + 5 + 6 = __ + 6

117 2nd through 4th graders with less than 75% correct at pretest on conceptual and procedural knowledge of mathematical equivalence

Pretest → One on One Intervention → Immediate Posttest → Delayed Retention Test

Three Conditions

Control (n = 39) Solve 6 problems

Self-Explain (n = 39) Solve 6 problems & explain

Additional-Practice (n = 39) Solve 12 problems

Matched for amount of practice

Matched for amount of time on task

Intervention Problems

6 + 3 + 4 = 6 + __ **3 + 4 + 8 = __ + 8**

Self-Explanation Prompts

Why does [7] make this a true number sentence?

What should you pay attention to to know that [7] makes the number sentence true?

What does the equal sign mean in this problem?

What should you pay attention to to know that the equal sign belongs here?

Procedure

Practice Problem → Accuracy Feedbck → Math Eq. Problem 1 → Strategy Report → Accuracy Feedbck → Self-Exp. Prompts 1 & 2 → Math Eq. Problem 2 → Strategy Report → Accuracy Feedbck → Self-Exp. Prompts 3 & 4

3+4+8 = __

3+4+8 = __ + 8

Why does 7 make this a true number sentence?
What should to pay attention to to know 7 makes the number sentence true?

3+4+8 = 5 + __

x 4 Sets

What does the equal sign means in this problem?
What should you pay attention to to know that the equal sign belongs here?

Fluent vs. Disfluent

16 explanation response. Coded as disfluent if:

Contained a pause, 'umm', or required additional experimenter prompting

Of the **39** students in the self-explanation condition, **19** were fluent (21sec) and **13** were disfluent (27sec).

Disfluent Explainers ≥ 4 Disfluencies

The numbers. [Exp. "Can you tell me more?"] The numbers... um… when you subtracting problems…you know where it goes.

[Long struggling] It equals 5. [Exp: Okay, can you tell me a little bit more?] The equal sign means the sum.

Umm… it means you, umm, you kinda, umm… added those… and it kinda, you kinda made it a 5.

Fluent Explainers < 3 Disfluences

Because I know that 10 plus 7 equals 17 just like 5 plus 3 plus 9.

The first side equals the second side, that is what an equal sign is.

The equal sign means they would be the same sum, the answer. It has to be the same answer, but it doesn't have to be the same number as the beginning…The equal sign means that

Assessment Components

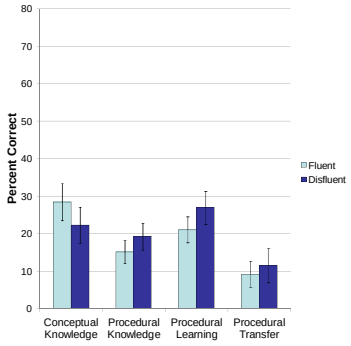
Knowledge of equivalence is typically assessed through
(e.g., Rittle-Johnson, Matthews, Taylor & McEldoon, 2011; Behr, Erlwanger, & Nichols, 1980; Falkner, Levi, & Carpenter, 1999 , McNeil, 2007; Rittle-Johnson & Alibali, 1999)

Conceptual Knowledge	Procedural Knowledge
Explicit- Equal Sign Knowledge	**Learning Items**- Same as those practiced during the intervention
What does the equal sign mean?	7 + 6 + 4 = 7 + __
Implicit- Equation Structure Knowledge	**Transfer Items**- Different from those practiced during the intervention
3 + 5 = 5 + 3 True or False	8 + __ = 8 + 6 + 4 6 - 4 + 3 = __ + 3

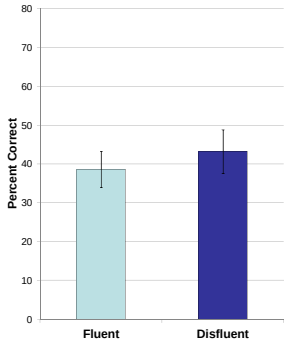
Results

Post & Retention Tests

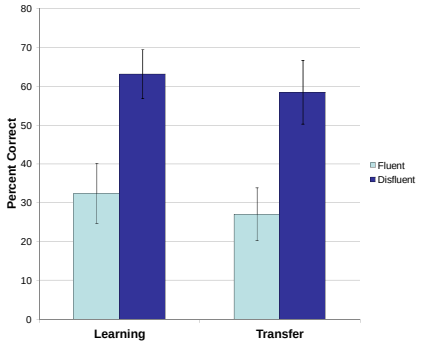
Pretest



Conceptual Knowledge



Procedural Knowledge



Summary

Elementary students who were verbally imprecise have better problem solving skills at post and retention tests than those who had precise explanations.

When students are prompted to self-explain, they engage in a learning process where they move from an initial imperfect understanding of equivalence to a correct understanding. Verbal imprecisions, such as saying 'umm', pausing, or requiring addition prompting from the experimenter, may indicate a conflict between their initial imperfect mental model and the correct one. Processing this conflict, as evidenced by verbal imprecision, may help them perform better on solving learning items and more difficult items after intervention.

"When children are imprecise while explaining … [we presume they are] in the process of rejecting old, presumably inefficient or ineffective problem-solving approaches." (Perry & Lewis, 1999)

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