Self-Explanation Improves Mathematics Learning in Low Prior Knowledge Students

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Current Focus

Is self-explanation effective for learners with low prior knowledge?

Self-Explanation

Self-explanation, or generating explanations to oneself in an attempt to make sense of new information, can promote learning (e.g. Rittle-Johnson, 2006).

Self-explanation has been found to be beneficial, even against rigorous time on task controls (McEldoon, Durkin, & Rittle-Johnson, 2012).
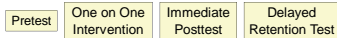
The learning benefits of this activity have not been investigated specifically in low prior knowledge learners, who may not be as able to successfully utilize explanation for learning.

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

$$6 + 3 + 4 = 6 + \_\_ \qquad 3 + 4 + 8 = \_\_ + 8$$
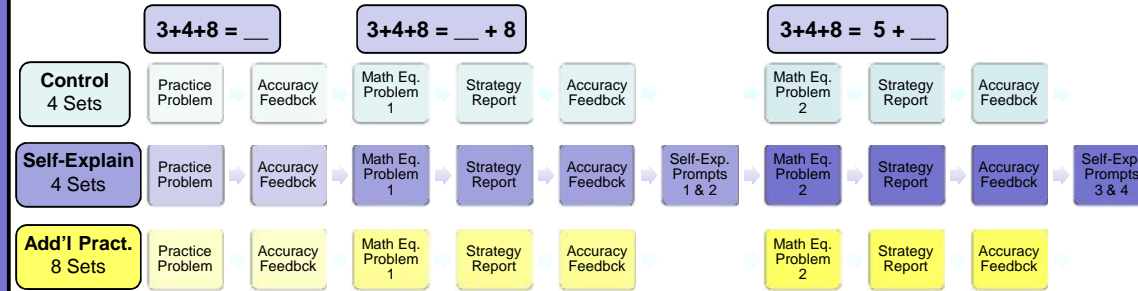
Self-Explanation Prompts

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

$$3+4+8 = \_\_ \qquad 3+4+8 = \_\_ + 8 \qquad 3+4+8 = 5 + \_\_$$

Control 4 Sets: Practice Problem → Accuracy Feedbck → Math Eq. Problem 1 → Strategy Report → Accuracy Feedback → Math Eq. Problem 2 → Strategy Report → Accuracy Feedback

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

Add'l Pract. 8 Sets: Practice Problem → Accuracy Feedbck → Math Eq. Problem 1 → Strategy Report → Accuracy Feedback → Math Eq. Problem 2 → Strategy Report → Accuracy Feedback

Low Prior Knowledge

A median split of pretest performance identified **55** low prior knowledge students

	N	Pretest Score	Conceptual	Procedural
Control	18	**11.2%**	10.6%	11.8%
Self-Explain	21	**11.9%**	11.9%	11.9%
Add'l Practice	16	**10%**	10.6%	9.4%

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

Equal Sign Knowledge

What does the equal sign mean?

Equation Structure Knowledge

$$3 + 5 = 5 + 3 \text{ True or False}$$

Procedural Knowledge

Learning Items- Same as those practiced during the intervention
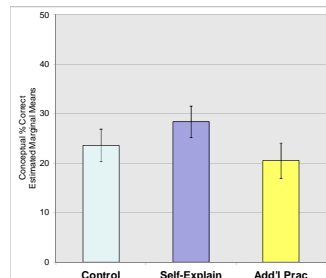
$$7 + 6 + 4 = 7 + \_\_$$

Transfer Items- Different from those practiced during the intervention

$$8 + \_\_ = 8 + 6 + 4 \qquad 6 - 4 + 3 = \_\_ + 3$$

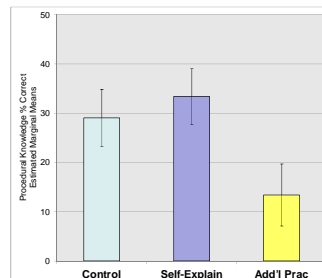## Results

Conceptual Knowledge

No Differences

Post & Retention Tests

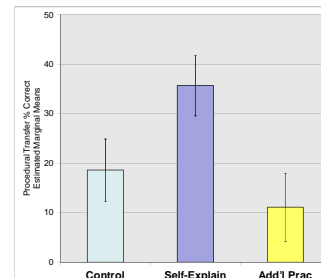#### Procedural Knowledge

Self-Explain **>** Addn'l Practice

Control **>M** Addn'l Practice

Procedural Transfer

Self-Explain **>** Addn'l Practice

Self-Explain **>M** Control

Summary

These findings suggest that **prompts to self-explain are a useful activity even for low prior knowledge students**, who may not have a large knowledge base to draw from when constructing their explanations.

Additionally, **self-explanation** seems to be particularly effective for fostering **procedural transfer**. This ability to solve novel and more challenging problems is a very important and desirable educational outcome.

These findings also suggest that sometimes **less uninstructed problem solving practice is more**, as the control group often had higher posttest scores than additional-practice.

The findings suggest that self-explanation prompts have unique learning benefits for low-prior knowledge learners, even when compared to alternative uses of time.

References

Behr, M., Erlwanger, S., & Nichols, E. (1980). How children view the equals sign. *Mathematics Teaching*(92), 13-15.

Falkner, K. P., Levi, L., & Carpenter, T. P. (1999). Children's understanding of equality: A foundation for algebra. *Teaching Children Mathematics, 6*(4), 232-236.

McEldoon, K. L., Durkin, K. L., & Rittle-Johnson, B. (2012). Is self-explanation worth the time? A comparison to additional practice. *British Journal of Educational Psychology,* (0552), 1–18. doi:10.1111/j.2044-8279.2012.02083.x

McNeil, N. M. (2007). U-shaped development in math: 7-year-olds outperform 9-year-olds on equivalence problems. Developmental Psychology, 43(3), 687-695.

Rittle-Johnson, B., & Alibali, M. W. (1999). Conceptual and procedural knowledge of mathematics: Does one lead to the other? Journal of Educational Psychology, 91(1), 175-189.

Rittle-Johnson, B. (2006). Promoting transfer: effects of self-explanation and direct instruction. *Child development, 77*(1), 1–15. doi:10.1111/j.1467-8624.2006.00852.x

Rittle-Johnson, B., Matthews, P. G., Taylor, R. S., & McEldoon, K. L. (2011). Assessing knowledge of mathematical equivalence: A construct-modeling approach. *Journal of Educational Psychology, 103*(1), 85-104.

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