

Self-Explanation Prompts are Less Beneficial if Students Know More

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Success in Math Involves



- developing new mathematical problem-solving procedures
- understanding increasingly difficult concepts

To do this, students must integrate new information with relevant prior knowledge

Self-Explanation

Can support knowledge integration (e.g., Chi, et al 1994)

During instruction, self-explanation typically is prompted by showing students a correct procedure, answer, or text passage and asking them to explain the underlying rationale

$$3 + 7 = 3 + 7$$

Why is 7 the right answer?

Self-Explanation

Improves learning and transfer across a variety of domains

- 4-year olds completing repeating patterns
(Rittle-Johnson et al., 2007)
- Middle-school students learning geometry
(Wong et al., 2002)
- Bank apprentices learning to calculate interest
(Renkl et al., 1998)

Self-Explanation

Does not improve learning in all situations

- May not be more beneficial than other activities that take comparable time (e.g., extra problem solving)

(Matthews & Rittle-Johnson, 2009)

- Can even lead to worse performance

(Kuhn & Katz, 2009)

May be constraints on its utility

- Important to understand when it will benefit learning, in order to effectively implement in educational contexts

Considering Prior Knowledge

Individual differences in prior knowledge may influence when self-explanation is beneficial

- Math instruction often begins with formal instruction on critical concepts and is followed by problem-solving practice
- Therefore, students who already have some understanding of a topic may find that self-explanation is redundant with instruction

(Wittwer & Renkl, 2006, 2010)

Considering Prior Knowledge

Students with lower prior knowledge may benefit from self-explanations

Students with higher prior knowledge may benefit more from extra opportunities to practice (Anderson, 1982)

Math Equivalence

Two sides of the equation represent the same quantity

$$3 + 4 = 3 + 4$$

Children often treat the equal sign operationally

$$3 + 4 = \boxed{7} + 4$$

- “It means add the numbers” or “get the answer”

Need to get to a relational view

- Look at relations across both sides of the equal sign

Important prerequisite for understanding algebra, even in early grades (NCTM, 2006)

Procedure

Pretest

- 2nd-4th graders
- Suburban public school
- Selected if scored < 80%
- $N = 79$

Intervention & Immediate Posttest

- 2 Problem-Solving Conditions:
self-explain ($n = 40$), extra-practice ($n = 39$)

Retention Test (≈ 2 weeks)

Math Equivalence Assessment

Procedural knowledge

- Solving problems correctly

$$3 + 7 + 8 = 3 + \square$$

Conceptual knowledge

- Explicitly understand concept of equivalence

What does the equal sign mean?
Is this a good definition of the equal sign?

Pretest

ES1. What does the equal sign (=) mean?

It means sum or difference.

Retention

ES1. What does the equal sign (=) mean?

It means that 2 things are the same like a scale.

Pretest

ES1. What does the equal sign (=) mean?

It tells the sum.
ex. $4 + 2 = 6$

Retention

ES1. What does the equal sign (=) mean?

It means both sides are the same.

Tutoring Intervention



Conceptual Instruction

$$3 + 4 = 3 + 4$$

There are two sides to this problem...

*What the **equal sign** means is that the things on both sides of the equal sign are **equal** or **the same**...*

Problem Solving

$$3 + 4 + 8 = \square + 8$$

7 is the right answer.

Problem-Solving Conditions

Self-Explanation

Solve Problem 1

Explain Problem 1

Solve Problem 2

Explain Problem 2

Solve Problem 3

Explain Problem 3

Solve Problem 4

Explain Problem 4

Solve Problem 5

Explain Problem 5

Solve Problem 6

Explain Problem 6

Extra Practice

Solve Problem 1

Solve Problem 2

Solve Problem 3

Solve Problem 4

Solve Problem 5

Solve Problem 6

Solve Problem 7

Solve Problem 8

Solve Problem 9

Solve Problem 10

Solve Problem 11

Solve Problem 12

Tutoring Intervention



Self-Explanation Prompts

$$3 + 4 + 8 = 7 + 8$$

Ashley got 7, which is the right answer.

$$3 + 4 + 8 = 15 + 8$$

Madison got 15, which is a wrong answer.

Sample Explanations



$$3 + 7 = 3 + 7$$

Why is 7 the right answer?

“Because, um 3 plus 7 is 10. And then on the other side, it shows that 3 +, and you're trying to find out what, what other number equals 10. And 7 was the answer.”

$$3 + 7 = 3 + 13$$

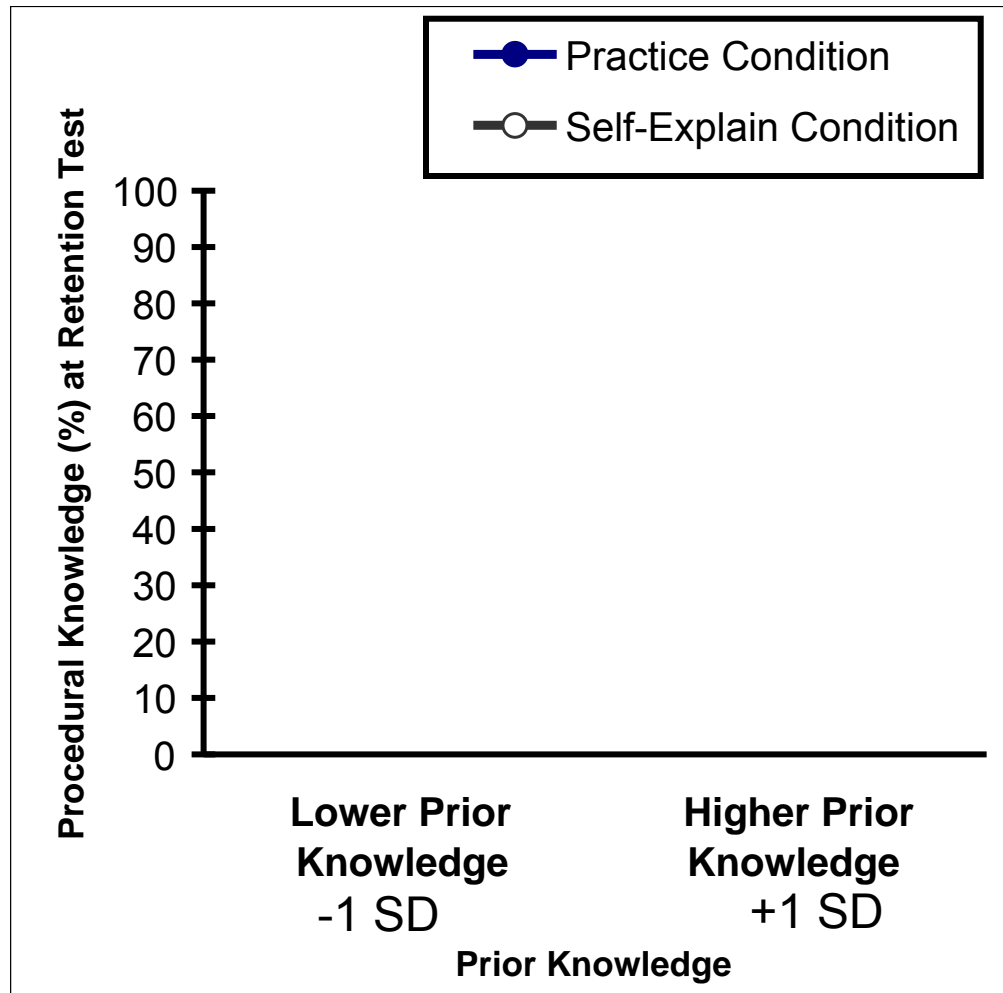
Why is 13 a wrong answer?

“Um it's the wrong answer because if 3 plus 13 that would be 16, and that equals 10 <pointing to left side>. And so she's basically kind of way off of the answer.”

Retention Test Results

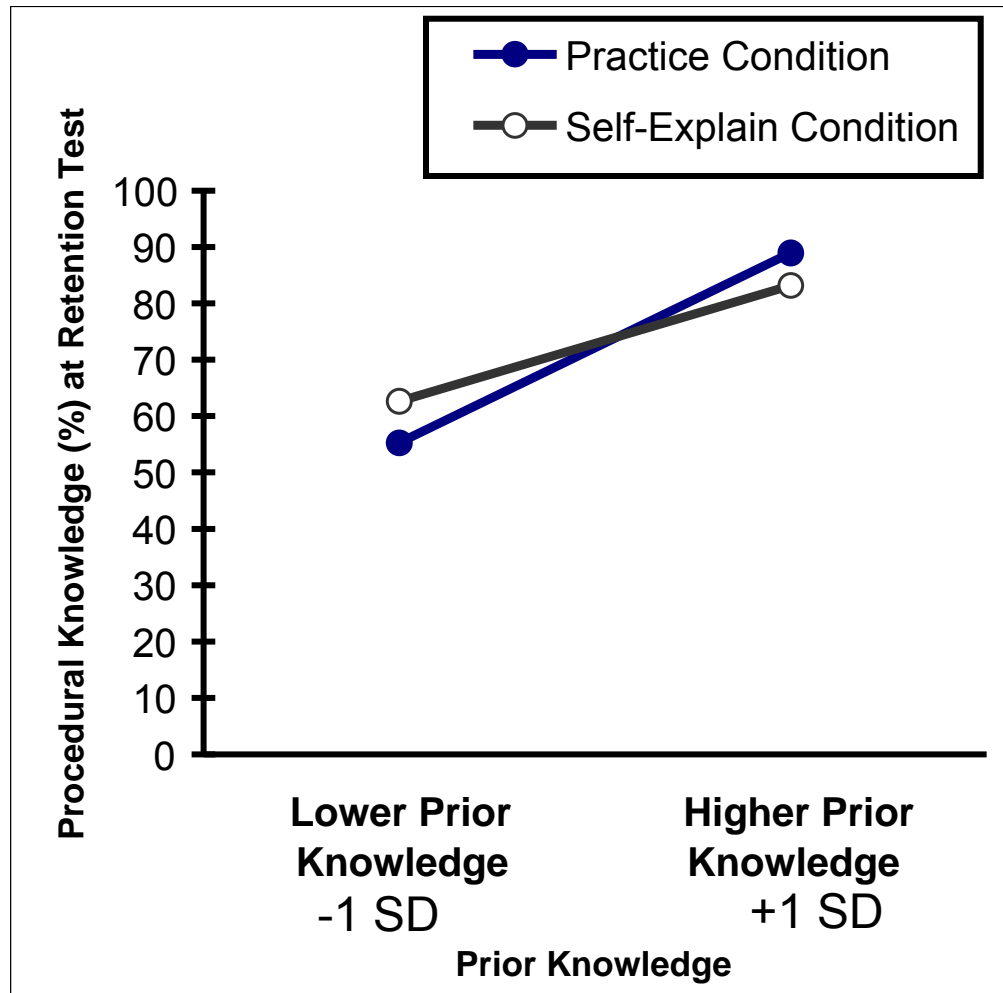
Retention Test Results

Procedural Knowledge (Problem Solving)



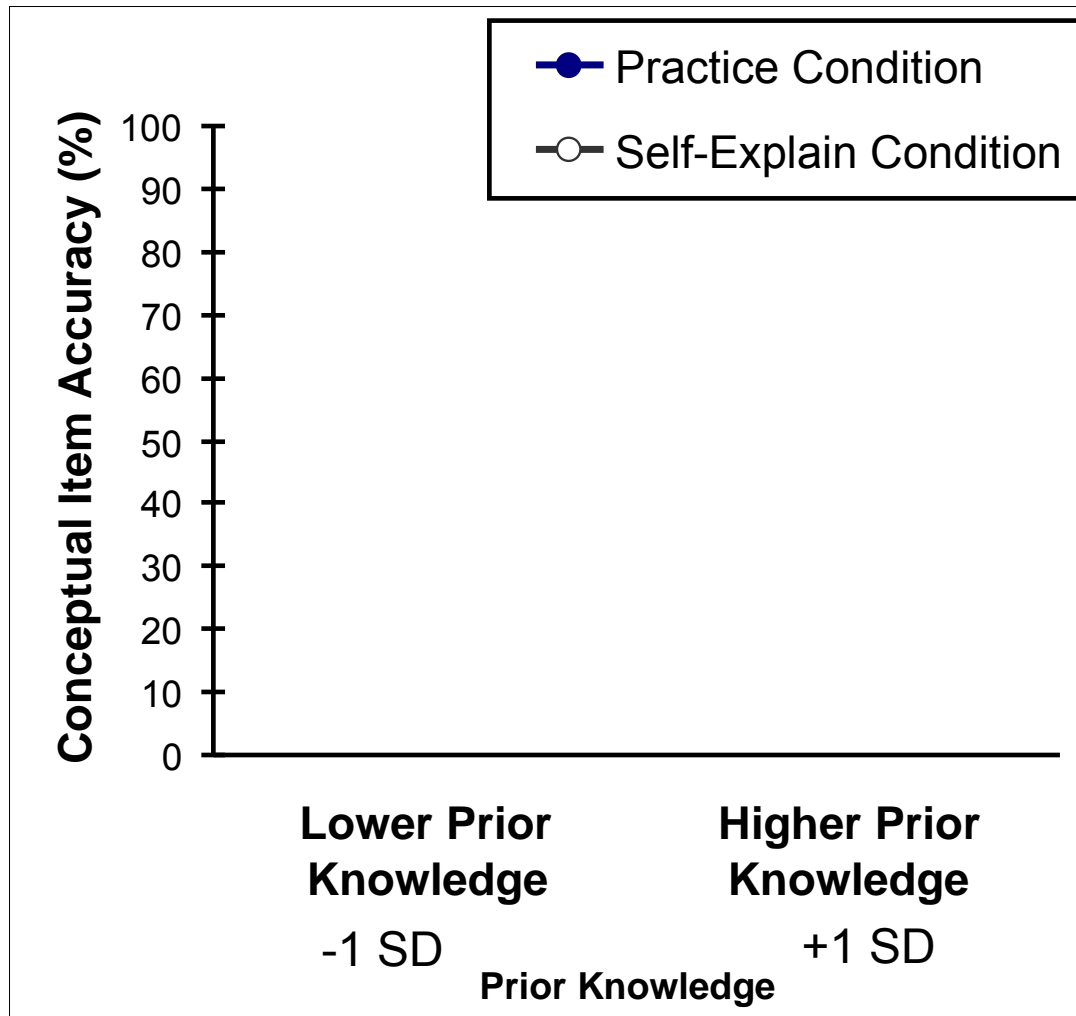
Retention Test Results

Procedural Knowledge (Problem Solving)



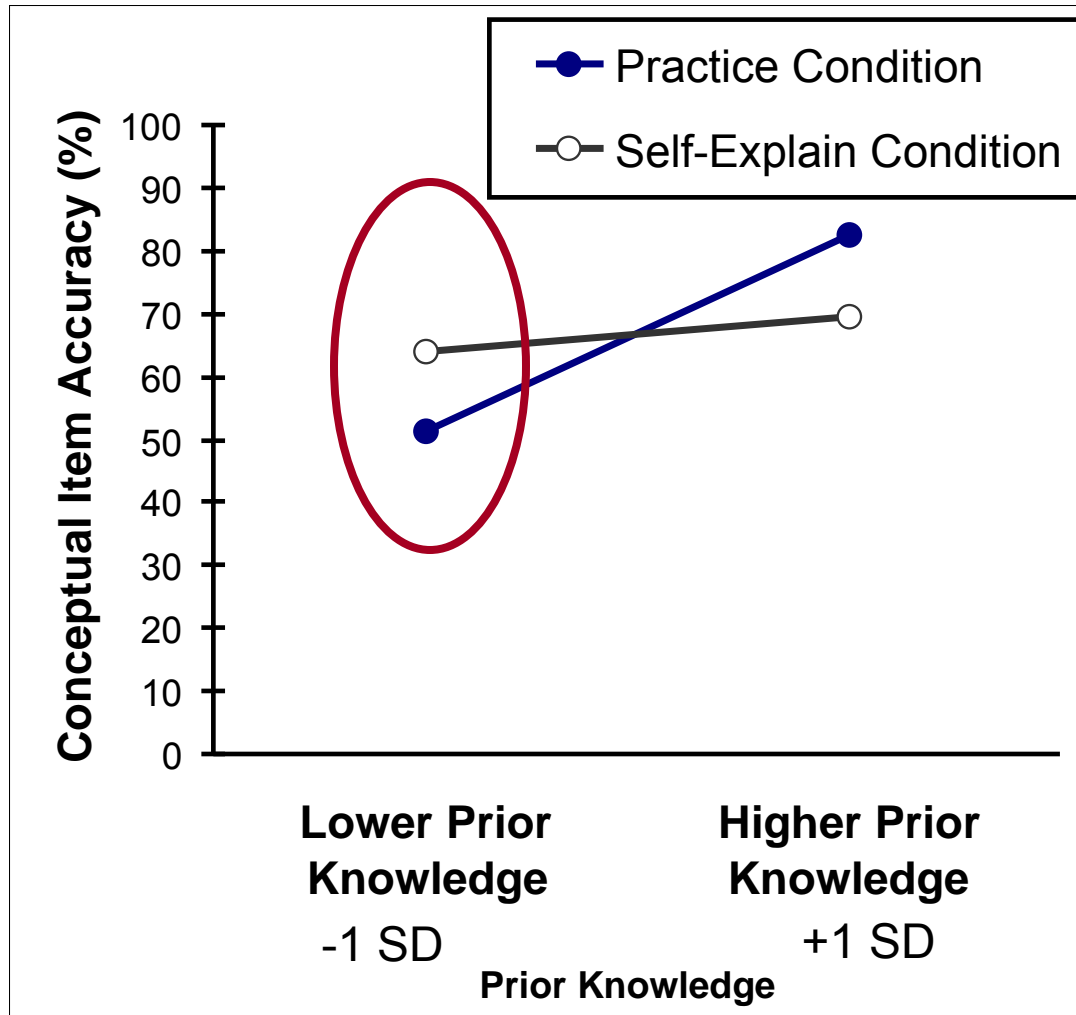
Retention Test Results

Conceptual Knowledge



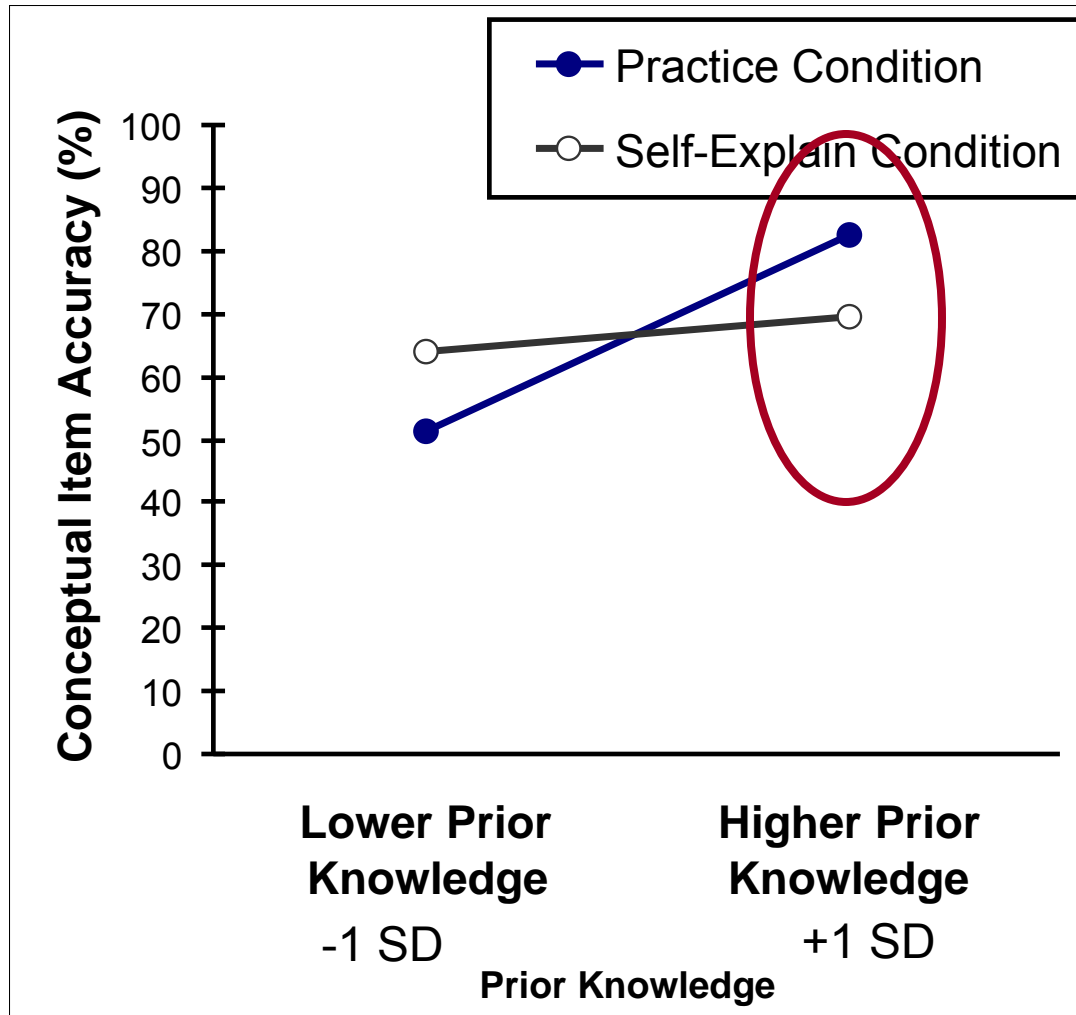
Retention Test Results

Conceptual Knowledge



Retention Test Results

Conceptual Knowledge



Summary

Prior conceptual knowledge influenced whether self-explanation benefited learning

- Lower-knowledge students benefited (compared to doing extra practice problems)
- Higher-knowledge students did not benefit (compared to doing extra practice problems)

Discussion

Self-explanation may help **lower-knowledge students** integrate new instruction with their prior knowledge

But it may be a redundant activity for **higher-knowledge students**

- They may disengage from the activity
(e.g., Kuhn & Katz, 2009; Pressley et al., 1992; Wittwer & Renkl, 2006)
- Extra practice may be more beneficial, helping them solidify the knowledge they have integrated during instruction and practice

Discussion

Important to consider individual abilities when designing instruction

Initial demonstration of an important caveat to using self-explanation as an instructional tool:

Self-explanation is better for lower-knowledge students, but may be less beneficial if students know more

Limitation: Short-term, individual instruction, on a specific math topic

Need to test for generalization

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