Preparing to Learn from Math Instruction

Mastery-Oriented Students Benefit Most from Exploratory Activities

Marci S. DeCaro

University of Louisville

Daniel A. DeCaro

Indiana University

Bethany Rittle-Johnson

Vanderbilt University

Should children be taught new concepts directly…

or discover these ideas for themselves?

Direct Instruction

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Discovery Learning

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Lessens burden on cognitive resources

(Kirschner et al., 1996)

Discovery Learning

Increases motivation and depth of understanding

(Wise & O'Neill, 2009)

Direct Instruction

Lessens burden on cognitive resources

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How can aspects of both approaches be combined to improve learning?

Discovery Learning

Increases motivation and depth of understanding

(Wise & O'Neill, 2009)

Exploratory Activities May Help Children Learn from Instruction

Evidence

- College students who explored examples learned more deeply from a psychology lecture than those who summarized a text

  (Schwartz & Bransford, 1998)

- 9th graders who explored datasets before instruction on descriptive statistics learned more from new instructional resources than those who received extended instruction

  (Schwartz & Martin, 2004)

Exploratory Activities May Help Children Learn from Instruction

Evidence

- These benefits are most apparent for complex problems requiring new insight

Individual Differences

Differences in how students respond to challenge may impact learning from exploratory experiences

Students approach learning with different goals and conceptions of “ideal” performance

(Hidi & Renninger, 2006)

Individual Differences

Students with **higher mastery-orientation**

- Motivated by a desire for personal growth
- Tend to view challenge (e.g., confusion, difficulty) as a signal there is an opportunity to learn and grow
- Generally respond to setbacks with increased effort and persistence
- Seek out challenge (e.g., new problem-solving experiences)

(Diener & Dweck, 1980)

Individual Differences

Students with **lower mastery-orientation**

- Do not especially appreciate the learning process itself (they want the answers)
- May even interpret challenge as signaling personal inadequacy and failure, causing them to withdraw from the activity

(Dweck & Leggett, 1988)

Current Study

Examined whether exploratory experiences (solving novel math problems) helped children learn from instruction at a deeper level

Because of individual differences in response to challenge, we anticipated that exploration would be more beneficial for higher mastery-oriented children

Math Equivalence

Operations on both sides of the equal sign 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"

Children need to have a relational view

- Look at relations across both sides of the equal sign

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

Instruction Conditions

Order

- Instruct – Solve
- Solve – Instruct

Hypotheses

- The Solve – Instruct order should improve conceptual knowledge (understanding at a deeper level)
- Mastery orientation should enhance this effect

  Children with higher mastery orientation should be better equipped to deal with the challenge

Procedure

Pretest

- 2nd-4th graders
- Suburban public school
- Selected if scored < 80% on Math Equivalence Assessment
- *N* = 159

Intervention & Immediate Posttest

Retention Test (after 2 weeks)

Mastery-Orientation Measure

Given at Pretest

Mastery-orientation score: Average of 2 items

- "In math class, I prefer course material that really challenges me so I can try new things"
- I want to learn as much as possible about math, even if I have to work hard.

☐	☐	☐	☐	☐	☐
1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Somewhat Agree	5 Agree	6 Strongly Agree

(Elliot, 1999)

Math Equivalence Assessment

Procedural knowledge

– Solving problems correctly

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

Conceptual knowledge

– Understand concept of equivalence

Is $4 + 8 = 8 + 4$ True or False?

What does the equal sign mean?

(Rittle-Johnson, Matthews, Taylor, & McEldoon, 2011)

Pretest

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

It means sum or differanse.

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?

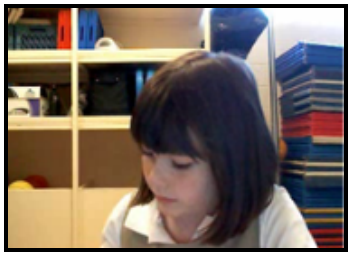
It tells the sum.
ex. 4+2=6

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**…*

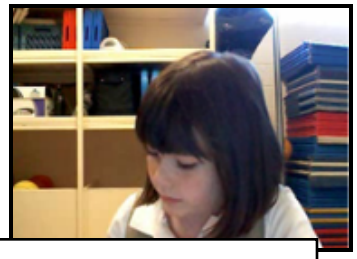
Problem Solving

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

How did you get your answer?

7 is the right answer.

Tutoring Intervention



Instruct – Solve

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 = □ + 8

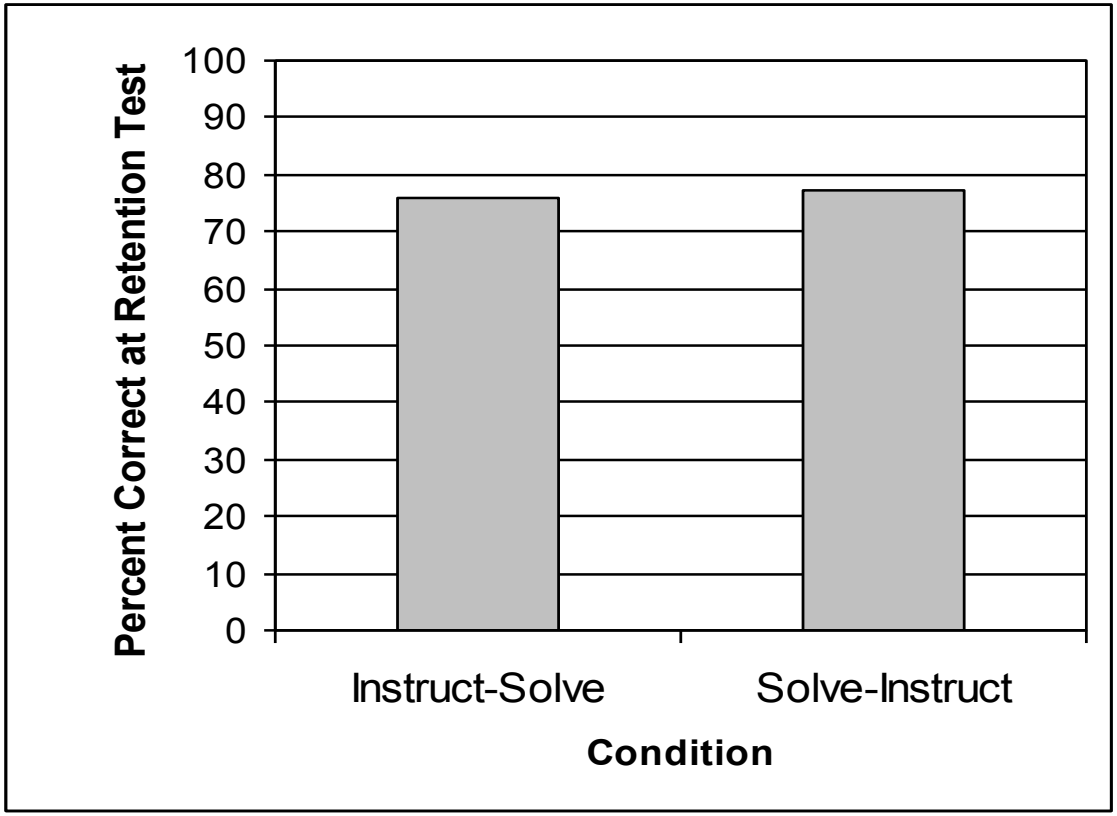
How did you get your answ

7 is the right answer.

Solve – Instruct

Retention Test Results

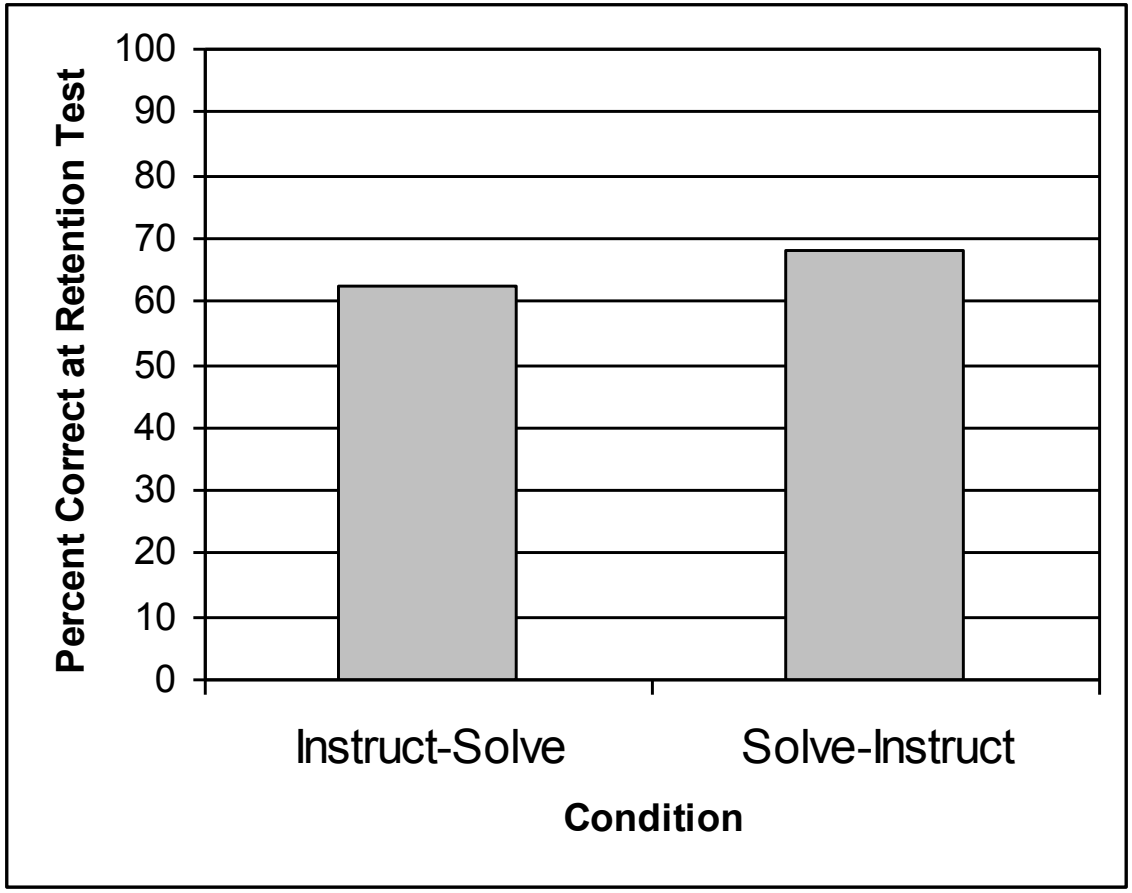
Procedural Knowledge (Problem Solving)



No effect of order or interaction

Retention Test Results

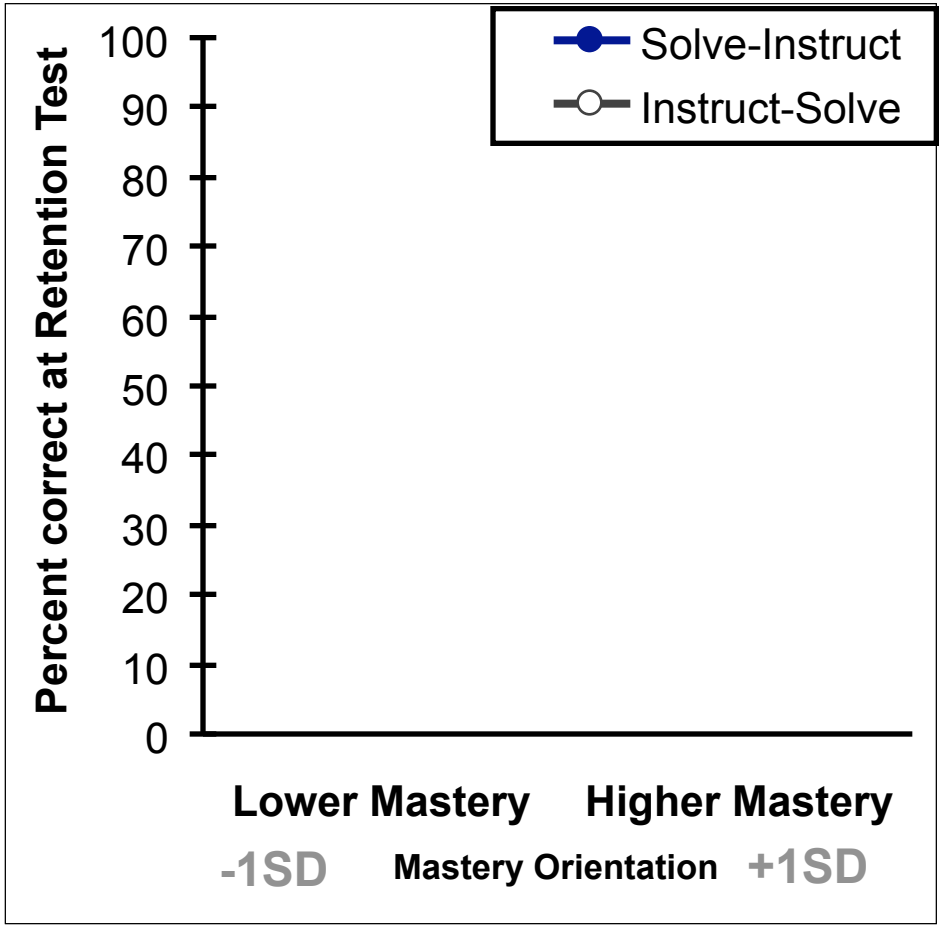
Conceptual Knowledge



Marginal effect of order, $p < .08$

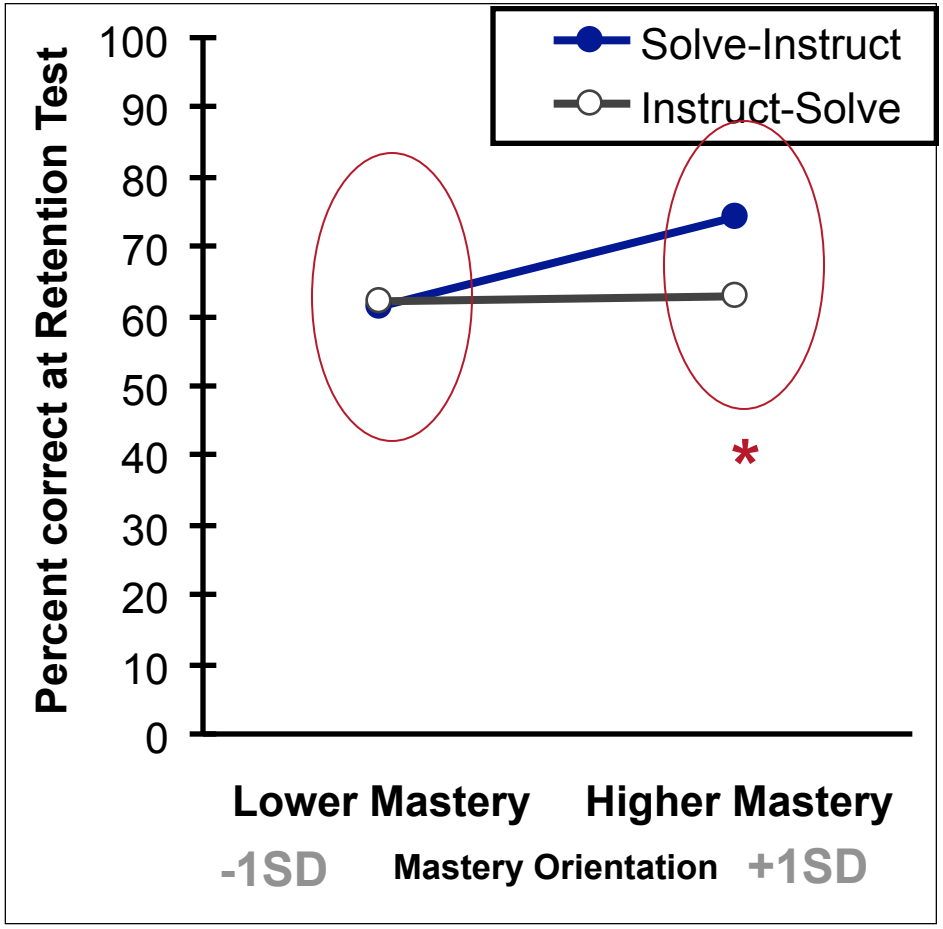
Retention Test Results

Conceptual Knowledge



Retention Test Results

Conceptual Knowledge



Summary

Exploring problems before instruction improved subsequent conceptual knowledge…

...But only for children higher in mastery-orientation

- Discovery learning activities can be challenging
- Mastery-oriented children tend to be more resilient to such challenges, approaching such activities with the goal to master and understand the content

Lower-mastery orientation did not benefit learning, but it did not hurt either

Conclusions

Overall, adding exploratory activities before instruction better than a coventional tell-then-practice approach

- One practical exploratory activity: Solve unfamiliar problems with feedback

Examines an important constraint

- Exploratory activities may be best suited for students who are most motivated for this type of challenge

Combines elements of discovery learning and direct instruction

- Joins a growing body of literature

(e.g., Schwartz & colleagues)

Conclusions

Future research is needed

- To replicate these findings with a more comprehensive mastery-orientation scale or direct observation
- To extend these findings to the classroom, in other domains, and with other types of exploratory activities
- To see if supporting mastery-orientation allows all students to benefit from exploration

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marci.decaro@louisville.edu
bethany.rittle-johnson@vanderbilt.edu

http://peabody.vanderbilt.edu/earlyalgebra.xml

ies INSTITUTE OF EDUCATION SCIENCES

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