



Are diagrams always helpful tools? The effect of presentation format on students' solutions of algebra problems

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Background:

- Problem representation is an important educational issue
 - Presentation format can have a big impact on students' learning (e.g., Cummins et al., 1988)
- Two relevant dimensions for solving algebra problems
 - Equation vs. story format
 - Diagrams vs. no diagrams
- Verbal Advantage
 - Beginning algebra students are more successful solving algebra story problems than mathematically equivalent equations (Koedinger & Nathan, 2004)
- Diagrammatic Advantage
 - Pictorial representations (charts, graphs, and tables) are often used in math classrooms because they are thought to be useful for helping students communicate and reason about mathematical concepts (Greeno & Hall, 1997)
 - Would diagrams help students solve algebra problems?

Purposes:

- Replicate Verbal Advantage
- Examine whether there is a Diagrammatic Advantage in solving algebra story problems
- Determine if there are developmental differences in either advantage
- Begin to examine mechanism behind why diagrams may or may not be helpful

Experiment 1: Method

- Participants: 373 middle school students
 - 121 Sixth Grade
 - 117 Seventh Grade
 - 135 Eighth Grade
- Procedure
 - Written test including many types of problems
 - 3 algebra problems presented as equations, story, or story + diagram
 - Three counterbalanced forms of the test; each of the three problems was represented in each of the three formats for one of the forms

Example of Problem Formats

Equation:

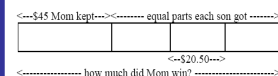
Solve the equation below to find the value of N:
 $(N + 45) \div 3 = 20.50$

Story:

Mom won some money in a lottery. She kept \$45 for herself and gave each of her 3 sons an equal portion of the rest. If each son got \$20.50, how much did Mom win?

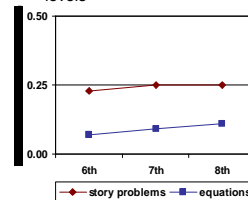
Story + Diagram:

Mom won some money in a lottery. She kept \$45 for herself and gave each of her 3 sons an equal portion of the rest. If each son got \$20.50, how much did Mom win? (You can use the picture below to help you solve the problem.)



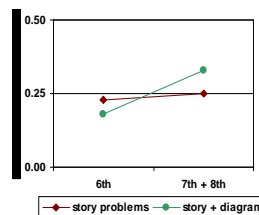
Experiment 1: Verbal Advantage:

- Story problems easier than equations $F(1,371) = 31.95, p < .01$
 - No grade effect; same at all grade levels



Experiment 1: Diagrammatic Advantage:

- Trend toward interaction:
 - 6th graders better without diagrams, 7th and 8th graders better with diagrams. $F(1,371) = 3.36, p < .10$



Experiment 1 Summary of Results

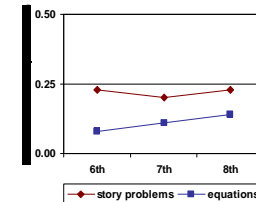
- Verbal advantage was replicated
- Potential diagrammatic advantage was found for older students, but not for younger students.

Experiment 2: Method

- Participants
 - 84 students who participated in Experiment 1 as sixth graders
- Procedure
 - Same as Experiment 1; students took the same test as seventh and eighth graders

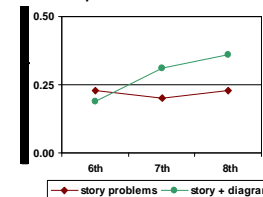
Experiment 2: Verbal Advantage:

- Story problems easier than equations $F(1,83) = 4.61, p < .05$
 - No grade effect; same at all grade levels



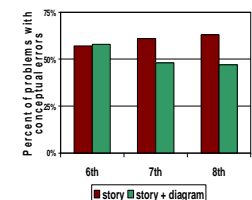
Experiment 2: Diagrammatic Advantage:

- Better without diagrams in 6th grade; with diagrams in 7th and 8th grades. $F(2,82) = 5.75, p < .05$



Why do diagrams help older students?

- Protect against conceptual errors
 - Of students that attempted the problems, students made fewer conceptual errors in 7th and 8th grades when diagram was given



Summary of Results

- Verbal advantage was replicated
 - No developmental differences—story problems are always easier
- Diagrammatic advantage is sometimes evident
 - Older students benefit, but not younger students.
- Diagrams may aid learning by protecting against conceptual errors
 - But only when students can use effectively them to understand the problem!

Future Questions:

- What is the mechanism underlying the diagrammatic advantage?
 - What types of conceptual errors does it protect against, and why?
- Would providing instruction on using diagrams increase the diagrammatic advantage?

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