

Arithmetic Practice that Promotes Conceptual Understanding and Computational Fluency: Year 3

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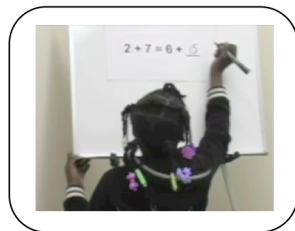


Abstract

We performed 3 experiments to test if arithmetic practice can be optimized to improve understanding of mathematical equivalence. Our first 2 experiments (Yrs 1 & 2) showed that modifications to the problem format and problem grouping benefited children's understanding. In this experiment, we tested the effect of modifying the symbols used to represent equivalence. Children (M age = 8;6) received practice with arithmetic and completed tests to assess their understanding of mathematical equivalence. Children were randomly assigned to 1 of 4 practice conditions: (a) traditional symbol, in which problems were presented with the equal sign (e.g., $5 + 4 = \underline{\quad}$) and equal bar (e.g., $5 + 4 = \overline{\quad}$), (b) nontraditional symbol, in which problems were presented with the equal sign, equal bar and relational words (e.g., $5 + 4$ is equal to $\underline{\quad}$), (c) word control, in which problems were presented with the equal sign, equal bar and operational words (e.g., $5 + 4$ adds up to $\underline{\quad}$), and (d) no-input control. Children in the nontraditional symbol condition encoded equations better and developed better computational fluency than children in the other conditions. Recently, we incorporated our 3 modifications into a nontraditional arithmetic practice workbook that is being tested in 2nd-grade classrooms.

Background

Mathematical equivalence is a fundamental concept in algebra, and success in algebra is crucial to future educational and employment opportunities.



Unfortunately, most children (ages 7-11) do not have a good understanding of mathematical equivalence. Misconceptions are robust and long term, persisting among high school and even college students.

We argue that difficulties are due to children's overly narrow experience with arithmetic in elementary school. Arithmetic is taught in a procedural fashion, with little or no reference to the equal sign or mathematical equivalence. Problems are almost always presented with the operations on the left side and the "answer" on the right, and they are typically grouped iteratively according to a traditional addition table. Moreover, equivalence is always symbolized with the equal sign or equal bar. These narrow experiences lead children to construct incorrect understandings of the equal sign, which are not easily overcome.

Background (cont.)

According to our account, arithmetic practice that is modified to be less narrow will promote understanding of mathematical equivalence. In experiment 1, we found that practice with nontraditional problem formats (e.g., $\underline{\quad} = 3 + 4$) promoted a better understanding than practice with traditional problem formats (e.g., $3 + 4 = \underline{\quad}$). In experiment 2, we found that practice with problems grouped by equivalent values led to a better understanding than did practice with problems grouped iteratively according to a traditional addition table.

In the present experiment, we tested the effect of the symbol used to represent equivalence. We hypothesized that practice that includes nontraditional symbols (i.e., relational words) would lead to a better understanding of mathematical equivalence than would practice with only the traditional symbols (i.e., equal sign and equal bar).

Method

Participants

142 children (M age = 8 yrs, 6 months; 80 girls, 62 boys; 69% white, 18% African American or black, 9% Hispanic or Latino, 3% Asian, and 1% multiethnic).

Procedure

Children played math games and answered flashcards during three 30-minute one-on-one sessions with a tutor. In between sessions, children completed short paper-and-pencil homework assignments.

Children were assessed on their understanding of mathematical equivalence at the end of the third session. Children later completed a five-minute follow-up assessment approximately two weeks after the third session.

Conditions

Traditional symbol– Problems presented with the equal sign and equal bar.

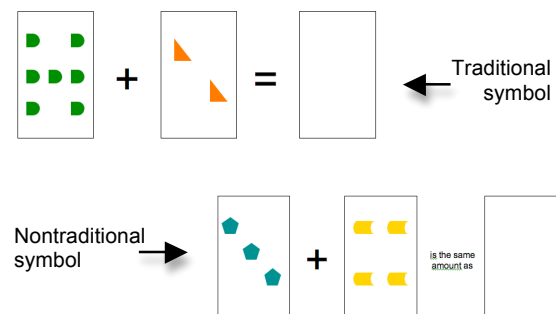
Nontraditional symbol– Problems presented with the equal sign, equal bar, and relational words: is equivalent to, is the same amount as, and is equal to.

Word control– Problems presented with the equal sign, equal bar, and operational words that children typically use in place of the equal sign: adds up to, makes, and equals.

No-input control– Children completed the assessments (described in next section) before receiving practice.

Method (cont.)

Example: Trad & Nontrad Versions of a Math Game



*We have traditional, nontraditional, and word control versions of all games and flashcards.

Assessments

Understanding of mathematical equivalence:

- Equation-solving performance– Solve and explain math equivalence problems (e.g., $1 + 5 = \underline{\quad} + 2$)
- Equation encoding– Reconstruct math equivalence problems after viewing for 5 sec.
- Equal sign understanding– Define the equal sign

Computational fluency:

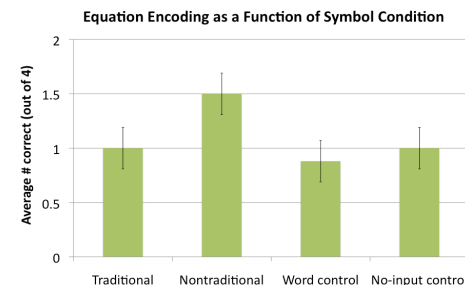
- Math Computation section of ITBS Level 8
- Single-digit addition facts (RT and strategy)

Follow up:

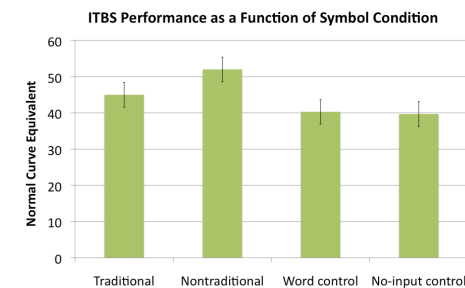
- Solve mathematical equivalence problems (with brief tutelage and feedback)

Results

Children who practiced problems with nontraditional symbols encoded equations better and developed better computational fluency than children in the other conditions.



Results (cont.)



Summary and Conclusions

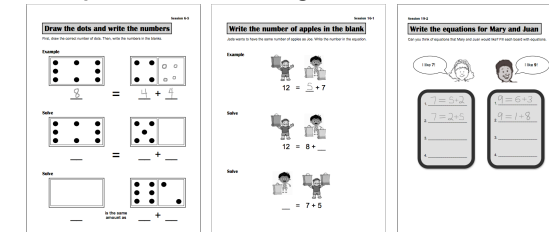
Results suggest that children benefit from practicing arithmetic problems that use nontraditional symbols (relational words) to represent equivalence.

Taken together with our previous experiments, results suggest that children benefit from relatively minor modifications that broaden their arithmetic practice.

Nontraditional Arithmetic Practice Workbook

We incorporated the 3 modifications into a nontraditional arithmetic practice workbook that is being compared to a traditional version of the workbook in 2nd-grade classrooms. Results from the workbook study will be reported next year.

Example Nontraditional Pages



Example Traditional Pages

