BACKGROUND

- Children need to learn step-by-step procedures and build understanding of central concepts (Blöte, Van der Burg, & Klein, 2001; Siebert et al., 1996).
- Many researchers advocate for direct instruction on both concepts and procedures (Kirschner, Sweller, & Clark, 2006; Klahr & Nigam, 2004; Roelofs et al., 2003; Sweller, 2003).
- Others suggest that instruction on procedures may limit children’s understanding by circumventing the need to invent procedures and by drawing attention away from concepts (Hiebert et al., 1996; Schwartz, Chase, Chin & Oppezzo, 2011; Perry, 1991).
- Opportunities to explore problems prior to instruction has also been shown to improve conceptual knowledge (DeCaro & Rittle-Johnson, 2012; Schwartz, Chase, Chin & Oppezzo, 2011), and instruction on both concepts and procedures may be more appropriate after opportunities to explore problems.
- Is it best to combine instruction on concepts and procedures or provide instruction on concepts only? Do opportunities to explore problems first reduce the impact of instruction type?

METHOD

Participants: 180 second-grade children from 13 classrooms (Mage = 7.6 years, range = 6.8 – 8.9; 55% female; 21% ethnic minorities)

Design

- In their math classrooms, children received a small-group lesson on math equivalence (i.e., the values on either side of the equal sign are the same amount) in one of four randomly assigned conditions based on crossing two factors:

1. Instruction Type:
   - **Conceptual instruction condition** received instruction focused on the relational meaning of the equal sign in the context of non-standard equations (e.g., 3 = 3 + 4). They received two iterations of conceptual instruction to equate instructional time across conditions.
   - **Combined instruction condition** received one iteration of conceptual instruction, followed by procedural instruction on a step-by-step procedure for solving two problems.

2. Instruction Order: Instruction before or after solving problems
   - **Instruct-Solve**: Received instruction first, followed by solving a packet of 17 problems independently (see sample pages). Checked their work and changed their answers if desired.
   - **Solve-Instruct**: Solved the 17 problems independently, with a few hints. Then received instruction. Finally, checked their work on the original problems, changing their answers if desired.

RESULTS

- No reliable differences between conditions at posttest.
- **Instruction type impacted knowledge retention**. Children who received only conceptual instruction had better retention of their conceptual and procedural knowledge than children who received combined instruction on concepts and procedures. Procedures, F(1, 174) = 6.24, p = .01, n2 = .04. Hedges’ g = .32 and F(1, 174) = 4.22, p = .04, n2 = .02. Hedges’ g = .26, respectively (see Figure).
- **Instruction order did not impact knowledge**. Children who solved problems before instruction did not have greater knowledge at retention test than children who solved problems after instruction, and instruction order did not interact with instruction type, Fs < 0.40, ps > .80.

DISCUSSION

- Focusing on conceptual knowledge may support knowledge retention because it is easier to remember things over time that make sense and are integrated with other knowledge (Baroody, Feil, & Johnson, 2007).
- Providing procedural instruction in addition to conceptual instruction may have guided attention away from reflecting on the conceptual instruction. Alternatively, reiterating conceptual instruction may be a more beneficial use of time than procedural instruction because students could easily invent successful procedures.
- Most past research has only compared combined conceptual and procedural instruction to no instruction or procedural instruction alone (Kirschner, Sweller, & Clark, 2006; Klahr & Nigam, 2004; Roelofs et al., 2003; Sweller, 2003). However, the benefits of combined instruction in these cases may be attributable to the lack of conceptual instruction in the control conditions.
- Opportunity to explore problems first did not reduce the impact of instruction type.
- Contrary to previous findings, opportunities to explore problems first did not support greater knowledge.

Assessment Materials: Sample Items (Adapted from Matthews et al., 2012)

<table>
<thead>
<tr>
<th>Item Type</th>
<th>Items</th>
<th>Scoring Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Procedural Knowledge</td>
<td>8 + 6 = □ 3 + 4 = □ + 5 7 + 6 + 4 = 7 + □</td>
<td>(μ = .85 at retention)</td>
</tr>
<tr>
<td>Transfer Problems</td>
<td>□ + 2 = 6 + 4 8 + 5 = 3 – 8 □ 7 + 2 = 3 □ + 3</td>
<td>Same as above</td>
</tr>
<tr>
<td>Conceptual Knowledge</td>
<td>What does the equal sign mean?</td>
<td>1 pt for providing relational definition (e.g., the same amount)</td>
</tr>
<tr>
<td>Structure of equations</td>
<td>Judge 3 = 3 and 7 = 3 + 4 as true or false</td>
<td>1 point for judging both equations as true</td>
</tr>
</tbody>
</table>

Effect of Instruction Type and Instruction Order at Retention Test

Lesson Materials: Problem Solving Packet

- No reliable differences between conditions at posttest.
- **Instruction type impacted knowledge retention**. Children who received only conceptual instruction had better retention of their conceptual and procedural knowledge than children who received combined instruction on concepts and procedures, F(1, 174) = 6.24, p = .01, n2 = .04. Hedges’ g = .32 and F(1, 174) = 4.22, p = .04, n2 = .02. Hedges’ g = .26, respectively (see Figure).
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References


Cognition and Instruction, 14, 251-283.


