Determining Effective Fraction Instruction Sequences

INTRODUCTION

- *Conceptual understanding* and *procedural fluency* are two of the five essential strands of mathematical proficiency (Kilpatrick et al., 2001)
- Math educators and researchers have worked to understand how conceptual and procedural knowledge develop, as doing so may inform how to sequence math instruction (Rittle-Johnson et al., 2015)
- Two competing theories, *concepts-first* and *iterative*, may explain how conceptual and procedural knowledge develop
    1. *Concepts-first* proposes that math concepts develop before procedures (e.g., a student must conceptually understand equivalence before accurately employing procedures to find a missing portion of an equation; Baroody, 2003)
    2. *Iterative* suggests concepts and procedures affect each other; a student's procedural practice improves conceptual knowledge, which, in turn, bolsters procedural understanding (Baroody, 2003; Rittle-Johnson et al., 2015)
- Recommendations from some math education experts (e.g., NCTM, 1989, 2000, 2014) tend to reflect a concepts-first approach, but some research studies support the iterative theory of development (Canobi, 2009; Hecht & Vagi, 2010)
- Rittle-Johnson and Koedinger (2009) tested both instruction sequences during a decimal intervention and found the iterative sequence resulted in better procedural learning and transfer—both groups performed equally well on the conceptual assessment
- Study purpose: to test the instruction sequences within a fraction intervention to see if the results from Rittle-Johnson and Koediner (2009) replicate

METHOD

- Five fourth-grade classrooms (114 students) were recruited to participate in a classwide academic intervention about fractions
- The intervention included twelve 20-min Direct Instruction lessons (Engelmann & Steely, 2005)
- Students were randomly assigned to one of three groups
    1. Concepts-first: conceptual instruction preceded procedural instruction (i.e., six lessons on fraction concepts followed by six on fraction procedures)
    2. Iterative: conceptual and procedural instruction were interleaved or alternated across all 12 lessons
    3. Control: students were not pulled for additional lessons, instead receiving more core curriculum in their general ed math class
- Only the order of the instruction, not the content, differed between groups
- Proximal outcome measures included researcher-created curriculum-based assessments to assess conceptual and procedural learning
- Distal outcome measures included published generalization fraction probes to assess transfer (Fuchs et al., 2020)

RESULTS

- Proximal outcome measures showed:
    - Intervention groups resulted in significantly improved performance over the control
    - Intervention groups performed similarly on conceptual measure
    - Iterative group outperformed concepts-first on procedural measure with a medium effect size (practically, but not statistically, significant)
- *No* differences between any of the three groups on distal, or generalization, assessments measuring skill transfer

Iterative instruction resulted in better procedural skill learning than ***concepts-first*** instruction during a **classwide fraction intervention**.

Both instruction sequences had comparable conceptual outcomes.

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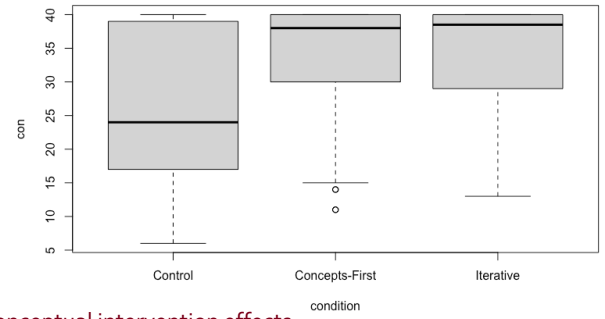
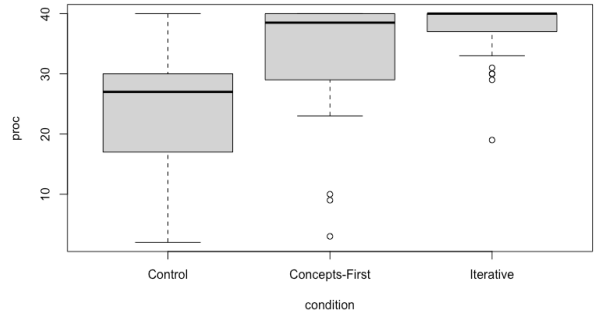


Conceptual intervention effects

Concepts-first v control: p = 0.005*, d = 0.69
Iterative v control: p = 0.004*, d = 0.76



Procedural intervention effects

Concepts-first v control: p < 0.001*, d = 1.02
Iterative v control: p < 0.001*, d = 1.85
Concepts-first v iterative: p = 0.07, d = 0.58

CONCLUSIONS

- This study provides some empirical evidence in favor of an iterative theory of development and instructional sequence
- Preliminary support for interleaving procedural and conceptual fraction instruction, especially for increasing procedural fluency
- Fraction skill generalization likely requires an intervention with increased frequency, longer duration, or higher intensity
- More evidence is needed to determine if this effect would hold for other math domains, as instruction sequence may affect math content differently
- Future research may test other instruction sequences (i.e., procedures-first instruction) alongside iterative and concepts-first to determine optimal sequence