



## Research Paper

## Using the virtual-abstract instructional sequence to teach addition of fractions



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## ABSTRACT

*Background/aims/methods:* Limited literature examines mathematics education for students with mild intellectual disability. This study investigated the effects of using the Virtual-Abstract instructional sequence to teach middle school students, predominantly with mild intellectual disability, to add fractions of unlike denominators. Researchers used a multiple probe across participants design to determine if a functional relation existed between the Virtual-Abstract instructional sequence strategy and students' ability to add fractions with unlike denominators. *Procedures/outcomes:* The study consisted of three-to-nine baseline sessions, 6–11 intervention sessions, and two maintenance sessions for each student. Data were collected on accuracy across five addition of fractions with unlike denominators problems.

*Results/conclusions:* The VA instructional strategy was effective in the students to add fractions with unlike denominators; a functional relation existed between the VA instructional sequence and adding fractions with unlike denominators for three of the four students.

*Implications:* The Virtual-Abstract instructional sequence may be appropriate to support students with mild intellectual disability in learning mathematics, especially when drawing or representing the mathematical concepts may prove challenging.

## What this paper adds

This paper adds to the limited literature examining mathematics education for students with mild intellectual disability as well as to the limited literature examining fraction instruction for this population as well as students with disabilities more generally. This paper also presents an alternative instructional sequence to the evidence-based Concrete-Representational-Abstract (CRA) instructional sequence.

## 1. Introduction

Fractions are considered an essential mathematical domain for students (National Mathematics Advisory Panel [NMAP, 2008]; Shin & Bryant, 2015). Procedural and conceptual knowledge of fractions are important for both understanding more advanced mathematical concepts in domains such as algebra, and for participating in daily activities such as cooking and personal finance (Jordan, Hansen, Fuchs, Siegler, Gersten, & Mickos, 2013; NMAP, 2008). The NMAP (2008) recommended students in middle school

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should be able to effectively carry out operations involving fractions, but also noted fractions are an area of significant difficulty for many students. Although many students struggle with fractions, students with disabilities tend to experience greater challenges with fractions (Hecht & Vagi, 2010; Misquitta, 2011).

To support the conceptual and procedural knowledge of fractions, researchers and professional organizations suggested different but related instructional approaches. Gersten et al. (2009), Doabler and Fien (2013), and the National Center on Intensive Intervention (2016) endorsed explicit instruction as an evidence-based practice in mathematics for students with disabilities; researchers also advocated for use of explicit students for students with intellectual and developmental disabilities (Browder et al., 2012; Root, Browder, Saunders, & Lo, 2017). Siegler et al. (2010), as well as the National Council of Teachers of Mathematics, noted the value in using representations to support fraction instruction (Shin & Bryant, 2015). Finally, researchers found a gradual sequence of instruction – such as the Concrete-Representational-Abstract (CRA) – to be effective in the teaching of fractions (Butler, Miller, Crehan, Babbitt, & Piece, 2003; Jordan, Miller, & Mercer, 1999; Misquitta, 2011).

The CRA instructional sequence is an evidence-based practice for students with learning disabilities that increases conceptual and procedural knowledge in a variety of mathematics domains, including fractions (Agrawal & Morin, 2016; Bouck, Satsangi, & Park, 2017; Misquitta, 2011). However, researchers have also explored the CRA instructional sequence for students with mild intellectual disability and autism, although less research exists (e.g., Bouck, Park, & Nickell, 2017; Stroizer, Hinton, Flores, & Terry, 2015). The CRA instructional sequence involves a graduated sequence of instruction across three phases. Concrete manipulatives (e.g., base 10 blocks, fraction strips) are used in the first phase to physically illustrate a mathematical concept in conjunction with abstract mathematical notation. As students gain mastery in the concrete phase, the physical manipulatives are replaced by visual representations (e.g., students draw representations). Students complete the final phase using only abstract mathematical notation and mathematical strategies. Explicit instruction is embedded within the CRA instructional framework as teachers model and think aloud (i.e., narrate or verbalize their problem-solving approach), proceed to guided practice, and then provide independent practice during each phase of instruction (Agrawal & Morin, 2016; Bouck Satsangi et al., 2017). Typically, students do not proceed to the next phase in the CRA sequence (i.e., concrete to representational) until they achieve mastery with the previous phase, generally defined as 80% correct for three intervention sessions (Bouck Satsangi et al., 2017; Cass, Cates, & Smith, 2003).

While the CRA instructional sequence and the use of concrete manipulatives are well supported in mathematics instruction for students with disabilities (Bouck & Park, *in press*), in recent years, researchers explored virtual manipulatives as a promising alternative to concrete manipulatives. For teachers, virtual tools may alleviate some of the concerns present with concrete manipulatives (e.g., running out of needed items, management concerns [e.g., kids playing the concrete tools for fun rather than using them for mathematical purposes]). Virtual manipulatives are also more transportable and potentially engaging for students (Bouck et al., 2012; Satsangi & Miller, 2017). Virtual methods may also be preferable for students in secondary school for whom concrete manipulatives may be stigmatizing (Satsangi & Bouck, 2015). App-based or online manipulatives may be more socially acceptable given the increasing focus in schools on use of technology (Bouck, Working, & Bone, 2017; Satsangi & Bouck, 2015; Satsangi & Miller, 2017).

Virtual manipulatives are pre-constructed digital versions of concrete manipulatives and include both online manipulatives and app-based manipulatives (Bouck & Flanagan, 2010; Bouck, Working et al., 2017; Bouck, Park et al., 2017). Examples of virtual manipulatives include base 10 tiles, fraction tiles, and other concrete manipulatives depicted as virtual objects; in other words, virtual manipulatives look similar to – if not exactly like – concrete manipulatives. Virtual manipulatives are different from the representational stage of the CRA, as in the representational stage students draw their own objects whereas with virtual manipulatives the objects are provided. Bouck, Shurr et al. (*under review*) compared the effects of concrete versus app-based manipulatives with three middle school students with a mild intellectual disability or learning disability when adding fractions with unlike denominators. Bouck, Shurr, et al. (*under review*) found both virtual and concrete manipulatives were effective in improving student accuracy and independence in completing problems. Two of the students indicated they would select the app-based manipulative when given a choice. The preference and similarity in effectiveness – for accuracy and independence – for virtual manipulatives is not unique to this study; other studies found virtual manipulatives effective and desirable replacements for concrete manipulatives (Bouck, Park, Shurr, Bassette, & Whorley, *under review*; Bouck, Satsangi, Taber-Doughty, & Courtney, 2014; Satsangi, Bouck, Taber-Doughty, Roberts, & Boefferdig, 2016).

Given the positive findings on virtual manipulatives to support mathematics teaching and learning for students with disabilities (Bouck et al., 2014; Satsangi et al., 2016), an emerging area of research is the Virtual-Representational-Abstract (VRA) instructional sequence. The VRA instructional sequence is an adapted version of the CRA in which students use virtual manipulatives rather than concrete manipulatives in the first phase of instruction (Bouck, Park, Shurr et al., *under review*; Bouck, Bassette et al., 2017). In a multiple probe across behaviors replicated across participants study, Bouck, Park, Shurr et al. (*under review*) explored the VRA instructional sequence to teach two middle school students with mild intellectual disability place value, single-digit addition with regrouping, subtraction with regrouping, and single-digit multiplication. The authors found a functional relation between the VRA instructional sequence and the acquisition of the mathematical behaviors.

Bouck, Bassette et al. (2017) specifically explored the VRA instructional sequence for fraction instruction. In this single case study, three middle school students with disabilities – inclusive of a student with a learning disability, a student with a mild intellectual disability, and a student who qualified under otherwise health impairment – used the Fraction Tiles app (Brainingcamp, 2017) to determine equivalent fractions (e.g.,  $\frac{2}{3} = \frac{\square}{6}$ ). The students each improved their performance over baseline when taught with the VRA sequence, and authors concluded the VRA instructional sequence was an effective intervention for these students. A functional relation was found between the VRA instructional sequence and students' ability to accurately solve equivalent fraction problems (Bouck, Bassette et al., 2017). While all three students indicated they enjoyed the virtual phase of instruction, two students disliked

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