Using the concrete-representational-abstract approach to support students with intellectual disability to solve change-making problems

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\textbf{A B S T R A C T}

\textbf{Background/aims/methods:} The Concrete-Representational-Abstract (CRA) instructional approach supports students with disabilities in mathematics. Yet, no research explores the use of the CRA approach to teach functional-based mathematics for this population and limited research explores the CRA approach for students who have a disability different from a learning disability, such as an intellectual disability. This study investigated the effects of using the CRA approach to teach middle school students in a self-contained mathematics class focused on functional-based mathematics to solve making change problems. Researchers used a multiple probe across participants design to determine if a functional relation existed between the CRA strategy and students' ability to solve making change problems.

\textbf{Procedures/outcomes:} The study of consisted of five-to-eight baseline sessions, 9–11 intervention sessions, and two maintenance sessions for each student. Data were collected on percentage of making change problems students solved correctly.

\textbf{Results/conclusions:} The CRA instructional strategy was effective in teaching all four participants to correctly solve the problems; a functional relation between the CRA approach and solving making change with coins problems across all participants was found.

\textbf{Implications:} The CRA instructional approach can be used to support students with mild intellectual disability or severe learning disabilities in learning functional-based mathematics, such as purchasing skills (i.e., making change).

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\textbf{What this paper adds?}
This paper adds to the limited literature examining the CRA approach to support students with disabilities in learning functional-based mathematics, such as purchasing skills. The CRA instructional sequence is an evidence-based approach to teaching students with learning disabilities, but additional research – such as this study – is needed to demonstrate its effectiveness with students with other disabilities, such as intellectual disability, and with more functional-based mathematics as opposed to more academic mathematics (e.g., double-digit subtraction with regrouping).

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1. Introduction

Functional (or life skills) mathematics – the mathematics related to living, working, participating, and accessing services in everyday life – is important for all individuals, but particularly students with disabilities (Burton, Anderson, Prater, & Dyches, 2013). Functional mathematics, like all functional domains (e.g., vocational skills and daily living skills), teaches students to maximize their own independence (Bouck & Joshi, 2012). Additional research, such as this study, is needed to find research-based approaches to teaching functional mathematical content to students with intellectual disability.

One important domain of life skills mathematics is purchasing skills (Alwell & Cobb, 2009; Xin, Grasso, Dipipi-Hoy, & Jitendra, 2005). Purchasing skills refer to the skills related to engaging in financial transactions to obtain services or goods (Browder, Spooner, & Trela, 2011); purchasing skills include such skills as navigating a store, comparing prices, and using money (e.g., making change; Mechling & Gast, 2003). Previous researchers suggested the value in helping students to become more independent with purchasing skills, including making change (c.f., Chihak & Grim, 2008). Chihak and Grim (2008) successfully taught purchasing skills to secondary students with autism and intellectual disability via the counting-on and next-dollar strategies. The students acquired as well as maintained and generalized the skills. In another study, Burton et al. (2013) found video self-modeling as an effective instructional strategy to teach students with autism and intellectual disability to estimate the amount they would need to pay for an item as well as the change they would receive.

As found by Burton et al. (2013), video modeling was an effective strategy for helping students with autism and intellectual disability determine the change they would receive from making a purchase. Video modeling is considered an evidence-based practice (Wong et al., 2014) and is used extensively to provide instruction to students with disabilities, particularly students with autism and intellectual disability (Ayres, Mechling, & Sansosti, 2013; Odom et al., 2015), including in mathematics. For example, Yakubova, Hughes, and Hornberger (2015) successfully used video modeling to teach three high school students with autism to solve more complex word problems. However, video modeling possesses limitations as well as benefits (e.g., effective strategy). For some schools the implementation of video modeling can be cost prohibitive, as they would need to purchase tablets (Weng & Bouck, 2014). Teachers have also expressed concerns that creating video models is both time consuming and challenging (Carnahan, Basham, Christman, & Hollinghead, 2012; Weng, Savage, & Bouck, 2014). This study examined an alternative approach to the effective and evidence-based approach of video modeling with regards to supporting students with intellectual disability in learning functional mathematics content, to provide teachers options to consider when teaching such mathematical content.

Researchers sought to find other effective mathematical strategies for students with disabilities. For example, some researchers explored the Concrete–Representational–Abstract (CRA) approach to teaching mathematics to students with autism and/or intellectual disability (Flores, Hinton, Stroizer, & Terry, 2014; Stroizer, Hinton, Flores, & Terry, 2015; Yakubova, Hughes, & Shinaberry, 2016). The previous studies of the CRA approach involving students with intellectual disability and/or autism suggest the benefit of such approach, with all demonstrating a functional relation between the CRA approach and students’ solving mathematical problems. However, the three previous studies examining the CRA approach for students with intellectual disability and/or autism involve basic operations, such as addition, subtraction, and multiplication (Flores et al., 2014; Stroizer et al., 2015; Yakubova et al., 2016). To date, no study examines the CRA approach to support functional mathematical content, such as change-making problems with students with intellectual disability or other disabilities. Hence, this study fills an important niche in the research base for both the CRA instructional strategy and for teaching mathematical content to students with intellectual disability.

The CRA approach is a graduated sequence of instruction, which moves students from solving mathematical problems (e.g., subtraction with regrouping) with concrete manipulatives (e.g., base 10 blocks) to solving the problems with drawings or representations of the objects (e.g., lines and dots). Finally, students learn to solve the problems abstractly, without any support or aids (Agrawal & Morin, 2016). The CRA approach is built upon the instructional strategy in mathematics known as explicit instruction; explicit instruction is considered an effective or recommended instructional approach for students with disabilities (Gersten et al., 2009). When a teacher uses explicit instruction in mathematics s/he models how to solve mathematical problems, such as subtraction with regrouping, through demonstrations and think-alouds. Next, the teacher moves onto providing prompts and cues as needed when students solve the problems themselves (i.e., guided instruction). Last, the students engage in independent practice in solving the mathematical problems (Doabler & Fien, 2013).

The CRA begins with teachers teaching students to solve a type of mathematics problem (e.g., multiplication with regrouping) with concrete manipulatives. To do so, teachers use the principles of explicit instruction to first model (i.e., demonstrate how to solve with the concrete manipulatives and use think-alouds to explain) with a few problems. Next, teachers guide students as they solve a few problems with the concrete manipulatives, meaning they provide prompts and cues as needed. Finally, students solve some mathematical problems independently with the concrete manipulatives. The same procedures are repeated for the representational phase in which students draw pictures or images to represent the concrete manipulatives, and then finally the abstract phase where students solve the problems without additional supports (Agrawal & Morin, 2016; Manci, Miller, & Kennedy, 2012). Generally, students need to achieve 80% correct or better across three sets of independently solved math problems to move from concrete to representational and then from representational to abstract (Manci et al., 2012).

The CRA approach has an extensive research base, spanning multiple decades and across different mathematical skill areas (e.g., place value, fractions, subtraction with regrouping, algebra) (Bouck & Park, 2016). Across the multiple studies – both single case design studies and group design studies, researchers found students were able to make gains in their
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