Research in Developmental Disabilities 35 (2014) 1828–1837

Contents lists available at ScienceDirect

Research in Developmental Disabilities

Effects of computer-based graphic organizers to solve one-step word problems for middle school students with mild intellectual disability: A preliminary study

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ARTICLE INFO

Article history:
Received 22 January 2014
Accepted 9 March 2014
Available online 16 May 2014

Keywords:
Computer-based graphic organizers
Kidspiration 3© software
Mathematics
Problem-solving
Word problems
Middle school
Mild intellectual disability

ABSTRACT

The purpose of this study was to examine the effects of computer-based graphic organizers, using *Kidspiration 3*© software, to solve one-step word problems. Participants included three students with mild intellectual disability enrolled in a functional academic skills curriculum in a self-contained classroom. A multiple probe single-subject research design (Horner & Baer, 1978) was used to evaluate the effectiveness of computer-based graphic organizers to solving mathematical one-step word problems. During the baseline phase, the students completed a teacher-generated worksheet that consisted of nine functional word problems in a traditional format using a pencil, paper, and a calculator. In the intervention and maintenance phases, the students were instructed to complete the word problems using a computer-based graphic organizer. Results indicated that all three of the students improved in their ability to solve the one-step word problems using computer-based graphic organizers compared to traditional instructional practices. Limitations of the study and recommendations for future research directions are discussed.

Problem-solving is one of the five core process standards in mathematics education (National Council of Teachers of Mathematics [NCTM], 2000; National Mathematics Advisory Panel, 2008). Most often, students learn and acquire problem-solving skills through solving *word problems* (Bates & Wiest, 2004; Jonassen, 2003; Levingston, Neef, & Cihon, 2009). The process of solving word problems; however, is a complex, multi-step procedure that requires students to read the problem, understand the meaning of the text, identify the relevant information embedded in the text, construct an abstract mental representation of the problem, make a decision on the solution steps, and finally, carry out those steps to solve the problem (Desoete, Roeyers, & De Clercq, 2003; Schumacher & Fuchs, 2012). In fact, recent research has shown that solving word problems is often a difficult and complicated task for a large number of students (Hart, 1996; National Assessment of Educational Progress, 2008; Zheng, Swanson, & Marcoulides, 2011) with disabilities (Fuchs, Seethaler, Powell, Hamlett, & Fletcher, 2008; Jitendra & Xin, 1997; Powell, 2011), including those with mild intellectual disability (MID) in mathematics

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http://dx.doi.org/10.1016/j.ridd.2014.03.023

instruction (see Butler, Miller, Lee, & Pierce, 2001; Hord & Bouck, 2012; Mastropieri, Bakken, & Scruggs, 1991; for reviews of the literature).

Students with MID commonly exhibit academic difficulties in areas such as basic reading, reading comprehension, language and mathematical computation skills, cognition and meta-cognition, and working memory, which are all critical skills needed to effectively solve word problems (Allor, Mathes, Champlin, & Cheatham, 2009; Geary, 1994; Geary, Brown, & Samaranayake, 1991; Katims, 2001). Despite these challenges, research indicates that students with mild intellectual disability may be, to some extent, able to learn and develop cognitive and meta-cognitive strategies for solving simple word problems (Erez & Peled, 2001). Thus, further research is needed to identify and provide these students with evidence-based interventions to promote higher-level mathematical skills for solving word problems relevant to function in everyday life situations. However, although an extensive amount of research on effective mathematics interventions can be found in the research literature; focusing primarily on students with learning disabilities (see Adams & Carnine, 2003; Baker, Gersten, & Lee, 2002; Browder, Spooner, Ahlgrim-Delzell, Harris, & Wakeman, 2008; Gersten et al., 2009; Kroesbergen & Van Luit, 2003; Xin & Jitendra, 1999; Zhang & Xin, 2012; Zheng, Flynn, & Swanson, 2013; for recent meta-analyses), only five studies have been conducted on word problem solving instructional strategies for students with mild intellectual disability (Cassel & Reid, 1996; Chung & Tam, 2005; Jaspers & Van Lieshout, 1994; Mastropieri, Scruggs, & Shian, 1997; Neef, Nelles, Iwata, & Page, 2003).

In the first study, Jaspers and Van Lieshout (1994) used computer-based instruction to compare the effectiveness of text-analysis, external modeling, and a combination of both strategies to a control condition on the skills of eighty-four students with mild intellectual disability to solve one-step addition and subtraction word problems. Text-analysis consisted of a four-step procedure which instructed the students to: (a) read a word problem presented on the computer screen, (b) identify the question being asked, (c) touch the words associated to the relevant sets and their relationships in the problem, and then (d) provide a numerical solution to the problem. Alternatively, in the external modeling strategy, the students were taught to model a solving strategy for each problem type using squares on the computer to represent the relevant sets and afterwards located the solution to the problem. Results indicated that the external modeling group outperformed the other groups when the students were asked to model and solve word problems using manipulatives. In contrast, students in the text-analysis group performed better than their peers on paper-and-pencil format tests. Reflecting on these findings, the authors conjectured that the text-analysis strategy promoted the acquisition of a mental representation of the word problems, which assisted the students in the text-analysis group to better determine the appropriate steps to solve the problems.

In the second study, Cassel and Reid (1996) evaluated the effectiveness of a nine-step self-regulated cognitive strategy with the use of the mnemonic ‘‘FAST DRAW’’ to enhance the problem-solving skills of two third graders with learning disabilities and two fourth graders with mild intellectual disability to solve four types of addition and subtraction word problems. Results revealed that all of the students markedly improved their ability to solve the four different types of addition and subtraction word problems and were able to correctly solve over 80% of the problems by the end of the study. Effects of the self-regulated problem-solving strategy were maintained 6 and 8 weeks after the conclusion of the study.

In the third study, Mastropieri et al. (1997) studied the effects of an animated computer-based tutorial to teach students a seven-step word problem-solving strategy to enhance the skills of four elementary-age students with mild intellectual disability to solve one-step addition and subtraction word problems. The seven-step problem-solving strategy consisted of: (a) read the problem, (b) form a mental picture of the problem, (c) determine the arithmetic operation, (d) write an arithmetic expression representing the problem, (e) compute the answer, (f) circle the solution, and (g) revise the steps completed to solve the problem. Results showed that students demonstrated significant gains on the number of word problems solved correctly from pretest to the online posttest; however, gains observed from pretest to the paper-and-pencil posttest were not significant.

In the fourth study, Neef et al. (2003) investigated the effects of teaching a series of ‘‘precurrent behaviors’’ to assist students with mild and moderate intellectual disability to solve change addition and subtraction word problems. Using sequential training, the students were progressively taught to identify the components of change word problems (i.e., initial set, change set, operation, and result set) on the text and filled in the appropriate boxes of a graphic organizer where the problem components were arranged as an arithmetic equation. Results indicated that the intervention improved the students' ability to recognize the four taught components on novel change word problems, which resulted in a substantial increase on the number of word problems the students answered correctly.

And finally, in the fifth study, Chung and Tam (2005) assessed the effects of three instructional strategies: (a) conventional instruction, (b) worked example instruction, and (c) 5-step cognitive strategy instruction on the problem-solving skills of thirty elementary-age Chinese students to solve two-step addition and subtraction problems. Results showed that the students in both the worked example and cognitive strategy instruction groups significantly outperformed those in the conventional instructional group from pretest to posttest and on delayed measures; however, no significant differences in performance were noted between the worked example and cognitive strategy instruction groups. Furthermore, the students in the worked example and cognitive strategy instruction groups did significantly better than the conventional group in problems similar to those taught during instruction and transfer problems as well; with no significant differences found between these groups.