Kingsdorf & Krawec, *Cogent Education* (2016), 3: 1135770
http://dx.doi.org/10.1080/2331186X.2015.1135770

cogent education

CURRICULUM & TEACHING STUDIES | REVIEW ARTICLE

A broad look at the literature on math word problem-solving interventions for third graders

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Received: 19 October 2015
Accepted: 18 December 2015
Published: 13 January 2016

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Reviewing editor:
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Abstract: Though research on effective instruction in math word problem solving is prominent at the middle and secondary levels, much less work has been done in elementary grades. In this article, we review the research on varied problem-solving instructional interventions at the third-grade level for students across ability levels. Third grade was chosen as the focus due to the fact that word problem-solving requirements are first introduced into the curriculum and standardized assessment at this point in time. Drawing on quantitative studies using single subject, quasi-experimental, and randomized controlled trial designs, we examine the instructional components and instructional content identified as effective across the 13 studies that met search criteria. Conclusions focus on current understanding of best practices, limitations of the existing research, and important considerations for future research.

Subjects: Classroom Practice; Education; Inclusion and Special Educational Needs; Mathematics; Primary/Elementary Education; Research Methods in Education; Teaching & Learning

Keywords: elementary school; learning disabilities (LD); at-risk; explicit instruction; self-strategies; multiple exemplars; Direct Instruction; visual representation models; schema instruction; problem-type

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Sheri Kingsdorf runs an applied behavior analysis consultation company that provides behavioral and educational support to staff working in public and private schools, home-based therapy settings, and day treatment centers. She remains active in academia through adjunct teaching positions and collaborative research projects with colleagues. Her research interests include behavior analytic intervention research related to skill acquisition in the populations of children with autism, learning disabilities, and English Language Learners (ELL). She hopes to further investigate the cognitive-behavioral framework introduced in this study within other academic subjects, additionally studying the role that Skinner's Verbal Behavior plays in the cognitive and behavioral processes associated with problem solving and comprehension.

PUBLIC INTEREST STATEMENT

Ensuring student success is always an educator's goal. However, for practitioners in particular, sifting through the research literature to find information on the most effective teaching strategies can be quite difficult. Additionally, making judgments about the applicability of the study to the current curricular targets can be daunting. Therefore, the goal of this paper is to provide an overview of the recent literature on math word problem-solving interventions for third-grade students. Numerous intervention strategies are critically evaluated, looking at areas which focus on prescribed instruction, instruction based on problem type, instruction based on using visual strategies, the use of varying teaching and practice models, and the use of student-driven strategies. In addition to strategy review, the curricular targets within each study are also clearly discussed. Overall conclusions are presented on best teaching and future research practices.

1. Introduction

As synthesized by Bryant and Bryant (2008), traditional word problem-solving instruction has proven ineffective for many students, especially those identified with or at risk of learning disabilities (LD), a group that struggles most with solving word problems. As a result, intervention research has surfaced that targets this population. This research has spanned grade levels, focusing predominantly on upper elementary and secondary students (e.g. Montague, Enders, & Dietz, 2011; Schaefer Whitby, 2009; Xin, Jitendra, & Deatline-Buchman, 2005). However, word problems are introduced early in the grade school curriculum, with their weight increasing in third grade, where high-stakes testing often initiates. Because curricular expectations of problem-solving proficiency are first presented at the third-grade level, it is vital that we find ways to promote student success in this area; research, particularly over the past 10 years, has begun to reflect this need. This increase in the third-grade problem-solving literature was made apparent when Powell (2011) conducted a review of second- and third-grade word problem-solving literature. However, the synthesis focused only on interventions which used schema instruction. While schema instruction is valuable, there are other notable instructional strategies which warrant review.

With third grade being where problem-solving requirements are first introduced into the curriculum and standardized assessment, and with the research starting to recognize the need for empirically validated strategies at this level, reviewing intervention research in this area with a critical focus can help provide a foundation for future research and drive practitioner recommendations. Therefore, this review aims to answer the following questions: What are the main instructional components being used in the third-grade problem-solving research? What instructional content has been the focus of the third-grade problem-solving research? How do the instructional components and content in the third-grade problem-solving research align with today's curricular standards? Where should future research in third-grade problem-solving research focus? What strategies should be recommended to practitioners to improve the word problem-solving skills of third graders?

2. Literature search

The studies selected for the review met two criteria. First, the treatments needed to target solving word problems. Second, the study participants needed to be in third grade. A comprehensive search of the empirical literature in electronic databases using the search terms *math*, *intervention*, *instruction*, *word*, and *problem*, followed by a manual review of the results for *third* (*3rd*), revealed 13 relevant studies conducted in the United States over the past two decades. Over 1,000 diverse third graders, identified across the categories of average achieving, at risk, low achieving, and special education (LD being the majority), participated in these studies. The intervention varied by setting (i.e. small-group resource rooms and inclusive classrooms) as well as by implementer, including researchers, teachers, and paraprofessionals. Outcome measures typically assessed word problem-solving accuracy using researcher-created measures. All of the studies used treatment packages for intervention, incorporating a number of instructional components, with significant overlap in many of the intervention procedures. Varying instructional content was identified as well.

Thus, characteristics of the 13 studies were identified either as *instructional components* of the intervention (i.e. the approaches or schema through which the problem-solving instruction was delivered, such as Direct Instruction (DI) and multiple exemplars) or as *instructional content* of the intervention (i.e. the parameters around the types of problems utilized in the intervention, such as single-step problems, change problems, addition problems, etc.). The following sections provide an in-depth analysis of the characteristics within each category, followed by a discussion of what we currently know about effective third-grade problem-solving instruction, limitations of that knowledge, and important directions for future research.

3. Literature review

3.1. Instructional components

Although each intervention identified a primary strategy, a number of instructional components enhanced these strategies. Additionally, intervention strategies were often given different names but shared the same instructional components. By carefully reviewing the studies, five instructional components were identified: (1) Direct Instruction (DI)/explicit instruction, (2) problem type, (3) multiple exemplars, (4) self-strategies, and (5) visual representation models. Table 1 identifies the instructional components within each study.

3.1.1. Direct Instruction/explicit instruction

DI is a comprehensive curricular approach which is largely scripted in nature and follows a specifically designed sequence (Marchand-Martella, Slocum, & Martella, 2004). Additionally, it involves logically sequencing skills, breaking down skills into smaller units, using clear and concise language, and providing step-by-step demonstrations, guided and supported practice, frequent opportunities for student responding, and immediate feedback. Explicit instruction and DI share these characteristics.

However, in contrast to DI, explicit instruction is more naturalistic and less scripted. Rather than requiring instructors to read from a script, explicit instruction follows a very specific procedure or set of guidelines. As originally presented by Engelmann and Carnine (1982), explicit instruction involves step-by-step teacher models and feedback to students during instruction. DI has a well-researched history of being an effective teaching strategy, especially for students with LD (Hicks, Bethune, Wood, Cooke, & Mims, 2011). This has also been the case for explicit instruction (e.g. Jitendra, Carnine, & Silbert, 1996). As a result, all 13 of the studies included either a DI or explicit instruction component; specifically, 12 studies used explicit instruction and one used DI.

Table 1. Study instructional components

	DI or explicit instruction	Problem type	Multiple exemplars	Self-strategies	Visual representation models
Wilson and Sindelar (1991)	x	x			
Fuchs, Fuchs, Prentice, Burch, Hamlett, Owen, Hosp, et al. (2003)	x	x	x		
Owen and Fuchs (2002)	x	x	x		
Fuchs, Seethaler, Powell, Hamlett, and Fletcher (2008)	x	x	x	x	
Fuchs, Fuchs, Craddock, Hollenbeck, Hamlett, and Schatschneider (2008)	x	x	x	x	
Fuchs, Fuchs, Prentice, Burch, Hamlett, Owen, and Schroeter (2003)	x	x	x	x	
Cassel and Reid (1996)	x	x		x	
Jitendra and Hoff (1996)	x	x			x
Jitendra et al. (1998)	x	x			x
Jitendra et al. (2007)	x	x			x
Griffin and Jitendra (2009)	x	x			x
Seo and Bryant (2012)	x			x	x
Leh and Jitendra (2013)	x	x			x

Though dated, Wilson and Sindelar (1991) conducted the only study investigating a DI-based intervention for solving math word problems. Sixty-two students with LD across grades two to five participated in the study. The DI portion of the intervention provided students with 14 scripted lessons on solving one-step addition and subtraction word problems. The sessions lasted 30 min and were run in a small-group setting. Results showed that the students receiving DI performed better than those students receiving other instruction. Unfortunately, very little information was provided on the specific skills being taught during DI intervention, making both replication and the ability to draw inferences about the most valuable areas of instruction for young students struggling with solving word problems difficult. In more recent third-grade studies using explicit instruction, more information on instructional procedures was provided.

Fuchs and colleagues have conducted numerous studies involving an explicit instruction approach to increasing the word problem-solving accuracy of third-grade students (Fuchs, Fuchs, Prentice, Burch, Hamlett, Owen, Hosp, et al., 2003; Fuchs, Fuchs, Prentice, Burch, Hamlett, Owen, & Schroeter, 2003; Fuchs, Seethaler, Powell, Fuchs, & Hamlett, 2008; Fuchs, Seethaler, Powell, Hamlett, & Fletcher, 2008; Owen & Fuchs, 2002). Throughout these interventions, students were explicitly taught rules for solving word problems, were provided with examples, and worked individually and in peer-mediated conditions to practice applying the strategies taught. In all studies, a control group was used, which incorporated standard district-based curriculum and teaching procedures. Earlier Fuchs and colleagues studies (Fuchs, Fuchs, Prentice, Burch, Hamlett, Owen, Hosp, et al., 2003; Fuchs, Fuchs, Prentice, Burch, Hamlett, Owen, & Schroeter, 2003; Owen & Fuchs, 2002) presented this explicit instruction in a general education, class-wide format. In the later studies, (Fuchs, Fuchs, et al., 2008; Fuchs, Seethaler, et al., 2008), intervention was provided through tutoring in a small-group setting as supplemental instruction. Intervention length varied across studies, ranging from three weeks to 16 weeks. In all studies, the treatment groups receiving an intervention with an explicit instruction component outperformed control group peers. However, in the study by Owen and Fuchs (2002), the accuracy of post-test scores for students with disabilities only reached 45%, raising questions about the distinction of success at the statistical versus practical levels.

There is another limitation to this research. Although this large body of research by Fuchs and colleagues involves a sizable and diverse sample of third graders, with all of the research being generated by one research team targeting the same geographical region of students, generalizability is in question. The classrooms that participated in this research are not likely to be typical of the majority of third-grade classrooms that are not supported by university-based research projects. These classrooms and teachers have likely had considerable support from these researchers over the years, making them comparatively different to usual third-grade classrooms.

While Jitendra and colleagues (Griffin & Jitendra, 2009; Jitendra, Griffin, Haria, et al., 2007; Jitendra & Hoff, 1996; Jitendra et al., 1998; Leh & Jitendra, 2013) also maintained a similar team to implement their intervention, they widely varied the location of their studies, lending generalizability to their findings and addressing this concern in previous research. In these studies, explicit instruction was again used to teach third graders strategies for solving word problems. Jitendra and Hoff (1996) used a single-subject design with intervention delivered in a small-group setting, which proved effective in increasing the problem-solving skills of students with LD. The other studies (Griffin & Jitendra, 2009; Jitendra, Griffin, Haria, et al., 2007; Jitendra et al., 1998; Leh & Jitendra, 2013), which used large group designs and targeted a diverse population of students, ran the intervention in an inclusive class-wide format. The majority of the studies (Jitendra, Griffin, Haria, et al., 2007; Jitendra et al., 1998; Leh & Jitendra, 2013) found that students in the condition using explicit instruction outperformed their control group peers.

Stand-alone studies using explicit instruction were conducted by Cassel and Reid (1996) and Seo and Bryant (2012). These studies used single-subject designs to evaluate the efficacy of explicitly teaching word problem-solving procedures to third graders identified with math difficulties or LD. In Seo and Bryant (2012) study, students were taught to use a four-strategy solving approach of reading, finding, drawing, and computing. In both studies, the explicit strategy intervention proved effective in increasing word problem-solving accuracy.

In conclusion, explicit instruction is a prominent component in the third-grade intervention research targeting word problem-solving instruction. It is clear that explicit instruction is a valuable method for teaching students a set of skills, strategies, or a solving process. None of these studies solely used explicit instruction, though. Therefore, to make determinations on the specific contributions of the skills, strategies, or processes targeted in each intervention through explicit instruction, their additional instructional components need to be analyzed.

3.1.2. Problem type

Teaching using problem type refers to teaching students to recognize patterns in problems and assign that problem to a previously taught category. This is also referred to as problem schemata identification (Jitendra, 2002). As discussed and supported by Jitendra, Griffin, Deatline-Buchman, and Sczesniak (2007), research on teaching students to identify specific characteristics of a problem has proven more valuable than teaching students to identify syntactic cues (e.g. key words). Different problem type categories have been identified in the literature (e.g. change, group, compare). However, there is a lack of consensus on the presence and applicability of these categories across grade levels. Regardless of the problem types targeted, when used as an instructional component, students are taught how to identify and match a problem's structural characteristics to previously provided plans for solving. This common intervention component was found in 12 of the 13 third-grade studies that were reviewed.

In Wilson and Sindelar's (1991) study, a problem-type instructional component was added to the DI lessons by teaching problems in a sequence based on problem type, though the specific problem type categories were not identified in this study. However, they found that teaching with this problem-type sequence in the context of the DI lessons was more effective than teaching using only the problem-sequence strategy or the DI lessons in isolation.

All of the Fuchs and colleagues' studies (Fuchs, Fuchs, et al., 2008; Fuchs, Fuchs, Prentice, Burch, Hamlett, Owen, Hosp, et al., 2003; Fuchs, Fuchs, Prentice, Burch, Hamlett, Owen, & Schroeter, 2003; Fuchs, Seethaler, et al., 2008; Owen & Fuchs, 2002) also found that teaching a problem-type strategy was effective in the context of explicit instruction. In three of the Fuchs studies (Fuchs, Fuchs, et al., 2008; Fuchs, Fuchs, Prentice, Burch, Hamlett, Owen, Hosp, et al., 2003; Fuchs, Fuchs, Prentice, Burch, Hamlett, Owen, & Schroeter, 2003), students were taught how to identify and apply solving rules for the four problem categories of (1) shopping-list problems, (2) half problems, (3) buying-bag problems, and (4) pictograph problems. In Owen and Fuchs (2002) study, only half problems were targeted (e.g. Every day John works an 8-h shift at the toy store. On Tuesday, he got sick and had to leave after 1/2 of his shift. How many hours did he work on Tuesday?). In Fuchs, Seethaler, Powell, Hamlett, and Fletcher (2008) study, problem types included total, change, and difference problems. All of these interventions used the procedure of teaching students to identify problem structures that corresponded to the problem types. For example, the students were taught to read the problem, underline the question, and then name the problem type by identifying the problem's underlying mathematical structure. Structure identification and problem naming were taught through practice with concrete examples and role playing through explicit instruction. After identifying the problem type, students were taught to follow the directions to solve the problem by following specific steps presented on posters for each problem type. Though it was reported that teachers used scripts in these studies to teach the problem-type identification and solution strategies, the structures that were taught to correspond with each problem type were not apparent in any of the studies; that is, the authors did not specifically outline what problem features students were taught to recognize to correspond with each problem category. The other prominent third-grade research team (i.e. Griffin & Jitendra, 2009; Jitendra & Hoff, 1996; Jitendra, Griffin, Haria, et al., 2007; Jitendra et al., 1998; Leh & Jitendra, 2013) also conducted problem-type research, but similar issues affecting replication were found.

All of Jitendra and colleagues studies (Griffin & Jitendra, 2009; Jitendra & Hoff, 1996; Jitendra, Griffin, Haria, et al., 2007; Jitendra et al., 1998; Leh & Jitendra, 2013) used problem-type categories similar to those used in Fuchs, Seethaler, Powell, Hamlett, and Fletcher (2008) study (i.e. change, group, and compare problems) and students were taught a procedure similar to that used in the Fuchs and colleagues studies to identify the problem type. The general procedure involved recognizing semantic features in the problem, matching the problem to the problem type, and designing a solution strategy and picking an operation. Cassel and Reid (1996) used similar problem categories, targeting equalize, combine, change, and compare problems. However, rather than teaching students to identify the problem type before solving, they taught students how to solve these problem types in a sequence (i.e. all of the combine problems were taught, then all of the change problems, etc.). This was also the case in Wilson and Sindelar (1991) study.

Explicitly teaching students to identify problem type before moving forward with the solving process has proven effective in some studies. This problem-type identification process involves students identifying important problem components to make a plan to solve. When students are taught using discrete problem types though, generalizability will become an issue. Some studies worked to address this problem by incorporating multiple exemplars in practice.

3.1.3. Multiple exemplars

Using multiple exemplars refers to using a range and sequence of examples in teaching procedures. Mathematics research has established the value of using multiple exemplars when teaching concepts to students (e.g. Witzel, Mercer, & Miller, 2003) in order to better establish their generalization and discrimination abilities. The studies reviewed here were identified as using multiple exemplars if a specific sequence of examples or systematic variation of examples were used. This follows the definition outlined in the meta-analysis on mathematical instructional components described by Gersten et al. (2009).

Five of the studies explicitly stated that they taught using multiple exemplars. All of these studies were conducted by Fuchs and colleagues (Fuchs, Fuchs, et al., 2008; Fuchs, Fuchs, Prentice, Burch, Hamlett, Owen, Hosp, et al., 2003; Fuchs, Fuchs, Prentice, Burch, Hamlett, Owen, & Schroeter, 2003; Fuchs, Seethaler, et al., 2008; Owen & Fuchs, 2002). In these studies, they termed their procedure "teaching for transfer," and investigated the effect of the procedure and whether it varied based on the number of novel problems included. The transfer procedure taught students to broadly group word problems requiring similar solutions based on sets of problem features, as well as how to apply this strategy to solving novel word problems. In all of their studies, the students taught with increasingly novel problems excelled in post-test conditions over their peers receiving the explicit intervention without this strategy. It makes sense that instruction using novel examples would have a positive effect on the generalization of an intervention; however, the novel examples used in their practice were still related to their narrow problem categories (i.e. shopping-list problems, half problems, buying-bag problems, pictograph problems, or total, change, and difference problems). Teaching students to work from such discrete examples makes them reliant on teachers to generate novel models for instruction in order to move the use of their solving strategies forward. One of the goals of intervention should be to teach strategies which have longevity and are initiated by students rather than teachers.

3.1.4. Self-strategies

Teaching using self-strategies is one way to work toward this student mediation of the problem-solving process. In intervention research, there are many variations of self-strategies, including self-regulation self-monitoring, self-management, self-recording, self-observation, self-assessment, and self-evaluation. All of these strategies typically include a student systematically monitoring his or her covert or overt behavior. These self-strategies have proven effective as instructional components of intervention packages for students with LD (Montague, 2008). The inclusion of these strategies is common in mathematics intervention research. A meta-analysis conducted by Kroesbergen and Van Luit (2003) found that, after DI/explicit instruction, self-instruction was the second most common intervention method used in mathematics interventions for students with special needs. Use of such strategies has been afforded some consideration in research on word problem-solving instruction for third graders.

Five of the thirteen studies included some components of self-strategies in their intervention (Cassel & Reid, 1996; Fuchs, Fuchs, et al., 2008; Fuchs, Fuchs, Prentice, Burch, Hamlett, Owen, & Schroeter, 2003; Fuchs, Seethaler, et al., 2008; Seo & Bryant, 2012); however, the specifics of those strategies differed in each study. In Cassel and Reid's (1996) study, the self-strategy components included individual student graphs (monitored by the students), a learning contract, and a self-monitoring strategy checklist with self-generated statements. All students in the study benefited from the use of these strategies, with the particularly interesting finding that students abandoned use of teacher-created scripts or prompt cards and began relying exclusively on their self-monitoring checklist, thus assuming control of their movement though the problem-solving process.

The older study by Fuchs and colleagues (Fuchs, Fuchs, Prentice, Burch, Hamlett, Owen, & Schroeter, 2003) made the use of self-strategies a systematic part of their intervention. They had students check their own work with an answer key, graph their individual scores, set goals for their subsequent scores, self-evaluate, and make self-report presentations to the class on how they generalized the problem procedure. The results of the study showed that the addition of the self-regulation strategies positively affected the post-test problem-solving scores, with the students in that group outperforming both other groups on even the most novel post-test word problems. The two more recent Fuchs and colleagues studies (Fuchs, Fuchs, et al., 2008; Fuchs, Seethaler, et al., 2008) did not cite the use of self-strategies as a primary part of their intervention; however, they incorporated self-monitoring and goal setting to aid in the intervention's efficacy. This was similar to Seo and Bryant (2012) study, where the self-regulation strategy steps of *do activity*, *ask activity*, and *check activi*ty statements (e.g. I read the problem for understanding. Does the picture fit the problem? I check that the number sentence and the answer are correct.) were embedded in their four-strategy solving approach, which proved effective.

It is a valuable contribution that the use of self-strategies proved effective in these few studies. This research is still limited though, and needs application in different types of intervention packages and with more diverse research teams and contexts.

3.1.5. Visual representation models

It has been established that one of the main problem-solving components in mathematics is representing the problem (Goldman, 1989; Stylianou & Silver, 2004). As a result, word problem instructional procedures that teach the use of visual representations have been researched and proven effective (e.g. Edens & Potter, 2008). A research synthesis by Jitendra and Xin (1997) found that visual representations were present in a number of word problem-solving interventions for students identified with, or at risk for, disabilities, as creating this graphic representation allows students to organize problem information and move forward in the problem-solving process (Jitendra, 2002). Effectively using graphic representations in solving math word problems involves more than just the use of diagrams. As supported by the studies below, visualizations used in solving mathematical word problems need to represent connections between the problem parts to effectively link the various phases of the problem-solving process (Gonsalves & Krawec, 2014).

About half of all reviewed studies focused on visual representation. All of the studies by Jitendra and colleagues (Griffin & Jitendra, 2009; Jitendra & Hoff, 1996; Jitendra, Griffin, Haria, et al., 2007; Jitendra et al., 1998; Leh & Jitendra, 2013) as well as Seo and Bryant (2012) study taught the use of visual representations as an instructional component. In Seo and Bryant (2012) study, teaching using visual representations was embedded within the larger computer-mediated intervention to solve word problems, though having students draw pictures was limited by the computer program's ability to represent the word problems. In contrast, in the studies by Jitendra and colleagues (Griffin & Jitendra, 2009; Jitendra & Hoff, 1996; Jitendra, Griffin, Haria, et al., 2007; Jitendra et al., 1998; Leh

& Jitendra, 2013), teaching using visual representations was noted as the key intervention component. The intervention provided students with teacher-created visual representation templates, which corresponded to the targeted problem types. Students were taught how to use the visual representation that corresponded with each problem type to recognize semantic features in the problem and match the problem to the problem type. Next, students were taught how to extend the use of the visual representations to design a solution strategy and pick an operation for computation. In one study (Jitendra, Griffin, Haria, et al., 2007), the pre-made diagram templates were faded out, with students being given the freedom to create their own. In the majority of the studies (Jitendra & Hoff, 1996; Jitendra, Griffin, Haria, et al., 2007; Jitendra et al., 1998; Leh & Jitendra, 2013), all students who received the visual representation intervention made improvements in comparison to their pre-test assessment and/or their control group peers. However, in Griffin and Jitendra (2009) study, students in the schema-based instructional (SBI) condition did not score higher in mathematical problem solving on standardized post-test scores than the students in the general strategy instruction (GSI) condition. Both conditions proved equally effective in improving word problem-solving performance. This is an interesting finding, but could be related to the similarity between the SBI and GSI conditions. The GSI condition was scripted and encouraged students to use strategies including manipulatives, drawing a diagram, writing a number sentence, and using data from a graph. Additionally, in one study (Jitendra, Griffin, Haria, et al., 2007), an analysis of the student subgroups of LD, English language learners (ELL), and Title I (students receiving free or reduced lunch) within the SBI group showed that students did not improve scores at initial post-test but did by maintenance. The somewhat limited results of Jitendra and colleagues' (Griffin & Jitendra, 2009; Jitendra, Griffin, Haria, et al., 2007) studies makes necessary additional research in the use of teaching visual representation strategies to student identified with or at risk for LD. Additionally, while teaching students to use visual representations when solving word problems is an important component of the problem-solving process, the use of the pre-made templates does little to support students in their use of generalizable problem-solving strategies. It is also worth noting that none of these studies incorporated self-strategies instruction, despite the strong evidence for its effectiveness. As apparent in the studies analyzed, teaching students to use visual representations does not result in a maximum level of effectiveness, if they are not also taught how to monitor and evaluate the use of their representation throughout the solving process.

3.1.6. Instructional components summary

A comprehensive review of the literature on third-grade problem-solving interventions for students at risk for or with LD sheds light on some key instructional components that have shown to be effective in improving students' problem-solving performance. It is established that explicit instruction is a necessary component of an effective problem-solving intervention. Teaching visual representations gives students a pictorial mode for determining their plan for problem solving. Using multiple exemplars in teaching has proven effective in increasing skill generalization, which in turn expands a student's use of the problem-solving process. However, multiple exemplars alone still make students reliant on teacher support to monitor the intervention and continually create novel problems. Incorporating self-strategies, though, establishes self-sufficiency in the problem-solving process and supports the reflection phase in particular. Teaching students to identify relevant information in the problem in order to make a plan to solve it is a key part of the solving process, and is a skill addressed when teaching the problem-type strategy. However, the instructional content within the problem-type strategy needs further review.

3.2. Instructional content

Evaluating the instructional components used in third-grade word problem-solving interventions is critical in determining intervention efficacy and effectiveness. However, interventions are comprised of not only instructional components, but also the content targeted through those components: instructional content. Critically evaluating the content targeted through intervention is important in determining intervention generalizability and overall efficacy.

Across grade levels, difficulty related to the operations, number of steps in problems, and targeted concepts varies, and research should reflect the level of difficulty expected of its sample population. According to the Common Core State Standards in mathematics (Common Core State Standards Initiative, 2012), third-grade level targets include solving problems using all four operations (addition, subtraction, multiplication, and division), fractions, measurement, estimation of time, liquid volume, masses of objects, and geometric measurement. After a careful review of the studies, it was clear that neither operations nor concepts met these standards.

3.2.1. Operations and steps

All of the studies reviewed targeted only addition and subtraction problems (Cassel & Reid, 1996; Fuchs, Fuchs, et al., 2008; Fuchs, Fuchs, Prentice, Burch, Hamlett, Owen, Hosp, et al., 2003; Fuchs, Fuchs, Prentice, Burch, Hamlett, Owen, & Schroeter, 2003; Fuchs, Seethaler, et al., 2008; Griffin & Jitendra, 2009; Jitendra & Hoff, 1996; Jitendra, Griffin, Haria, et al., 2007; Jitendra et al., 1998; Leh & Jitendra, 2013; Owen & Fuchs, 2002; Seo & Bryant, 2012; Wilson & Sindelar, 1991). It could be argued that students must first master the complex skill of problem solving with the more basic operations of addition and subtraction before moving onto multiplication and division. If this is the case, however, then follow-up procedures should have been provided in these studies on how the intervention was going to be extended to other operations. Without a plan for generalization, the students taught these discrete solving strategies for addition and subtraction are unlikely to transfer them to multiplication and division; further, some of the strategies cannot be extended beyond their current application. Additionally, when intervention time is spent on a remedial skill, students already at risk or identified may fall even farther behind in the curriculum. A few studies (Griffin & Jitendra, 2009; Jitendra, Griffin, Haria, et al., 2007; Leh & Jitendra, 2013) did try to plan for increased problem complexity by targeting two-step problems, but this was not the standard. This content limitation was also present in concepts targeted through problem categories.

3.2.2. Problem categories

While the use of a problem-type strategy (which teaches students to identify important information from a problem before building a plan for solving) has proven effective, the problem categories used in these studies raise questions about the generalizability of the procedure. In the study by Fuchs, Seethaler, Powell, Hamlett, and Fletcher (2008), the problem types included total, difference, and change problems. Similar problem types (i.e. change, group, and compare problems) were used in studies by Jitendra and colleagues (Griffin & Jitendra, 2009; Jitendra & Hoff, 1996; Jitendra, Griffin, Haria, et al., 2007; Jitendra et al., 1998; Leh & Jitendra, 2013). These problem types were described as: (1) total problems combining two or more quantities, (2) difference problems comparing two or more quantities, (3) change problems involving increasing or decreasing a starting quantity, (4) group problems, related to total problems, combining groups to form new groups, and (5) compare problems, related to difference problems, involving the comparison of two sets. The use of these problem types was rationalized by identifying them as most common in math curricula for grades 1–3. While some of these categories do seem to offer some growth potential (e.g. total problems), they are noted as prominent in the lower grades only; that is, these problem types will become obsolete after third grade, as problem “types” broaden with additional operations and multiple steps. These particular problem categories are directly related to the operations of addition and subtraction, making their application to more complex operations and problems that include multiple steps ineffective.

In the other work by Fuchs and colleagues (Fuchs, Fuchs, et al., 2008; Fuchs, Fuchs, Prentice, Burch, Hamlett, Owen, Hosp, et al., 2003; Fuchs, Fuchs, Prentice, Burch, Hamlett, Owen, & Schroeter, 2003; Owen & Fuchs, 2002), the problem categories used were even more narrow (shopping-list problems, pictograph problems, buying-bag problems, and/or half problems). These problem structures were not researcher created, but taken specifically from the *Math Advantage* (Burton, 1994) curriculum used in the target schools and specific to individual units. Therefore, the questions were not a composite of the most common problems used in the *Math Advantage* curriculum, but questions present in specific units. This is extremely limiting. These problem types are not likely to be present in any curriculum past the third grade, or even in other third-grade curriculums. For example, one such buying-bag problem reads as follows: "You want to buy some lemon drops. Lemon drops come in bags with 10 lemon drops in each bag. How many bags should you buy to get 32 lemon drops?" (Fuchs, Fuchs, Prentice, Burch, Hamlett, Owen, Hosp, et al., 2003, p. 305). The number of such "shopping-bag" problems these students will see again after the study is low if not non-existent and worse, when problems do happen to include a shopping bag, it is highly unlikely they would align to the particular structure taught; to say the least, this concern raises serious questions about the usefulness of such an instructional strategy.

Overall, the problem-types strategy as targeted in these interventions lacks growth potential. As is, these problem categories are basic and do not meet the level of complexity of the concepts targeted in accordance with the Common Core State Standards. As the curricular targets increase in complexity in grades four and five, students are expected to be solving problems that involve factors, multiples, decimals, measurement conversion, geometric measurement, multiplication and division of fractions, graphing, and multiple-digit multiplication and division. These skills move far beyond basic addition and subtraction word problems that use lists, halves, or pictograph contexts. Therefore, while an intervention must be focused and specific in order to improve performance on a certain skill, it should also be broad enough to produce measureable, practical gains in the classroom (and not just the research) setting.

3.2.3. Instructional content summary

The examination of the limitations set on problem-solving instructional content at the third-grade level indicates some areas needing improvement in these instructional interventions. For instruction to be effective, it must match a student's current level of academic functioning; yet, in the long term it is to the detriment of that student to maintain those parameters, particularly when they are far below grade level expectations. In general, the instructional content in the current body of research on third-grade problem-solving interventions does not meet the rigor of the widely adopted Common Core State Standards. Thus, the generalizability of the research findings to the types and complexity of problems characteristic of the Standards is not promising.

4. Conclusions and discussion

Mathematical word problem-solving literature was reviewed here, targeting interventions for third graders. Third-grade literature was chosen due to the introduction of this concept in curriculum and state assessments, in alignment with the adopted Common Core State Standards, at this early elementary level. Based on the findings of this comprehensive review of the literature of third-grade problem-solving interventions, it is clear that the intervention practices that most clearly support the problem-solving process include teacher-mediated explicit instruction with multiple exemplars to teach students to demonstrate understanding of the problem and work to solve it. Visual representation has been shown to effectively support students' concept formation and their ability to plan a viable solution path. Finally, self-strategies such as self-monitoring and self-correcting aid students in reflecting on, and checking, their work.

Practitioners should take these findings into consideration when targeting word problem-solving instruction. Basic instruction in solving word problems should be situated within an explicit instruction context; essentially, the problem-solving process should be broken down into smaller steps, the teacher should model all steps in the solving process, provide guided practice, use corrective and positive feedback that is immediate and specific, and allow time for independent solving before assessment. These lessons involving modeling and practice, at both the supported and independent levels, should involve multiple exemplars—so numerous examples which address all the key areas outlined in the Common Core State Standards. Another effective lesson component that should be included is the use of visual representations. Teachers should generate various visual models for solving, avoiding the use of a template, but rather allowing for multiple visual connections to be made which represent the main problem pieces and their relationship. Lastly, to ensure that accuracy later develops into fluency, self-strategies should be incorporated into instruction. Teaching a student to monitor his or her progress in the solving process builds confidence, independence, and generalization.

4.1. Limitations

It must be noted that all 13 of the studies included in this review improved students' math problem solving, indicating some level of effectiveness. It is the purpose of this review to identify these strengths but also highlight areas that can be improved in order to provide the optimal instructional package to the students who need it. First, the content of the interventions was not reflective of the full scope of the third-grade curriculum, thus limiting potential for growth to more mature mathematical concepts. This limitation was reflected in 12 of the 13 studies included in this review. Additionally, several of the studies lacked specificity in the implementation and procedures surrounding the instructional components, particularly related to DI/explicit instruction. Without clear procedures guiding implementation, fidelity is difficult to determine and replication is unlikely to occur. One final consideration that limits the impact of the current findings is the lack of practical significance reported in some of the studies (e.g. Owen & Fuchs, 2002). Statistically significant growth is critical to demonstrate measureable improvements, but if that growth translates to a still-failing school grade, the intervention has not fully met its objective.

No single research study stands alone as the answer to a problem; even with a body of research, it is important to examine the current state of knowledge to determine what works and also identify what warrants further investigation. Based on these conclusions, additional research is needed to investigate intervention packages which incorporate the instructional components shown to be effective but also consider the limitations identified in this review. Therefore, such future research should focus on investigating math word problem-solving interventions which align with the Common Core State Standards, use explicit instruction teaching methodologies, incorporate multiple exemplars in teaching and practice, teach the development of visual representation models, and involve self-strategies. Improving the problem-solving performance of students in elementary grades using these validated strategies will situate these students for successful math experiences in their middle and high school years and, ultimately, in their post-secondary careers.

Funding
The authors received no direct funding for this research.

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Citation information
Cite this article as: A broad look at the literature on math word problem-solving interventions for third graders, Sheri Kingsdorf & Jennifer Krawec, *Cogent Education* (2016), 3: 1135770.

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