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The Role of Teacher Training in Cognitive Strategy Instruction to Improve Math Problem Solving

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The purpose of this article is to offer teacher training and professional development recommendations in mathematics based on the findings of a federally funded 3-year intervention study that improved the problem solving of middle school students with a focus on students with learning disabilities. Over the 3-year project, 29 seventh and eighth grade teachers implemented a problem-solving intervention based on cognitive strategy instruction. Though the intervention was successful in improving students' problem-solving performance, several issues related to teaching effectiveness and teacher training came to light. The article will: (1) describe the intervention and its implementation, (2) present the findings of the study, and (3) discuss the issues of effectiveness and possible solutions via teacher education and professional development.

Despite the national movement toward a mathematical curriculum that develops conceptual understanding and application skills, many middle and high school students do not have the requisite skills and strategies to solve math word problems effectively and efficiently. Even students who have acquired the necessary math skills often lack important problem-solving strategies that would enable them to generalize the skills beyond the classroom. These deficits are often attributed to the shortcomings of classroom instruction as well as the increasingly advanced performance expectations for K-12 students (Hawley & Valli, 1999; Van Garderen, 2008). When teachers fail to effectively improve student problem-solving performance, it is imperative to examine the root of that failure. Linking student performance not just to teacher effectiveness but also to *teacher training* effectiveness may help identify specific weaknesses in teacher education and/or professional development (PD), which can then be addressed. It is important to note that many authors distinguish between teacher education (i.e., for preservice teachers) and PD (i.e., for in-service teachers; Sowder, 2007). Because the school-based research project that is the basis of this article utilized in-service teachers, PD will be the primary focus; however, findings related to PD can, and should, help inform teacher education programs as well.

PROBLEM SOLVING INSTRUCTION

Proficient math problem solving is essential for success in school, on the job, and in the community, and the current mathematics curriculum reflects the critical importance of problem-solving skills (National Council of Teachers of Mathematics [NCTM], 2000). Research on the instructional methods found to improve student mathematics performance has also impacted the way in which math is taught. Rather than emphasizing procedural knowledge and low-level computational skills through rote learning and repeated practice, teachers are encouraged to develop mathematical discourse among students through contextualized problem solving and by making explicit connections among concepts (NCTM, 2000; Sowder, 2007). Spillane (2000) further distinguishes between these two approaches, in which the former is characterized by "*procedural knowledge* [which] centers on computational procedures and involves memorizing and following predetermined steps to compute answers," and the latter by "*principled knowledge* [which] focuses on the mathematical ideas and concepts that undergird mathematical procedures" (p. 144).

The Role of PD

The relatively recent emphasis on principled knowledge represents a major departure from traditional math instruction. Particularly, for teachers with experience in the traditional curriculum, it is a value shift that requires substantial unlearning (Sowder, 2007). In order to make this pedagogical change permanent, effective PD is the key. According to Sowder, PD should not just focus on increasing mathematical content knowledge but include also "an understanding of how students think about and learn mathematics" (p. 163). Though in the past, PD has been criticized as ineffective and disconnected to actual teacher needs (e.g., Ball & Cohen, 1999; Lord, 1994; Miles, 1995), more recent research by Blank, Alas, and Smith (2007) analyzed the quality of select PD programs across several states and found that, compared

*Dr. Marjorie Montague passed away on 13 May 2012. She is sincerely missed but will be remembered fondly for her important contributions to the field of special education.

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to those in the mid 1990s, programs had improved drastically in structure as well as effectiveness. The majority of the programs provided important pedagogical knowledge in addition to content knowledge; emphasized research-based practices; utilized active methods for learning such as developing/presenting model lessons, providing opportunities for collaboration, and using coaching/mentoring. Effective PD also provided sufficient time for learning including follow-up work in schools; and made explicit connections to state content standards. Other research on effective PD corroborates the importance of these characteristics (e.g., Archibald, Coggshall, Croft, & Goe, 2011; Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009).

The Impact of PD

Yet, despite the evidence that PD opportunities have increased in both quality and quantity (Darling-Hammond et al., 2009), little is known about the degree to which the knowledge gained has transformed teacher practice in math instruction, particularly for students in special education (Van Garderen, 2008). Evidence from this study related to math instruction suggests that procedural knowledge, as taught through worked examples (i.e., where teachers solve a specific problem type on the board and then let it remain as a guide while students independently complete additional problems of the same type) and the application of rote steps (e.g., understand the problem, make a plan, carry out the plan, check the results), still characterizes the majority of problem-solving instruction (Montague, Enders, & Dietz, 2009). Almost no strategy instruction was evident during our observations of comparison of teachers' problem-solving instruction in middle school math classrooms despite the well-documented research on the effectiveness of this approach (MacArthur, 2012). Thus, there appears to be a gap between PD and its ability to transform classroom practice.

The purpose of this article is to offer teacher training and PD recommendations in mathematics, based on a recently completed 3-year intervention study that aimed to improve the math problem solving of middle school students. First, the intervention will be described. Then, the findings of the study will be discussed. Finally, recommendations for supporting general and special education teachers' implementation of the intervention and instructional implications based on study findings regarding PD and suggested enhancements to teacher education will be provided.

THE MIDDLE SCHOOL MATH PROJECT

The 3-year Middle School Math (MSM) project tested the efficacy of a cognitive strategy instructional intervention with seventh and eighth grade math students who were identified as average achieving, low achieving, or having LD. Previous research established its effectiveness when researchers provided instruction, but while the studies showed that the intervention was effective for students with LD (e.g., Montague, 1992; Montague, Applegate, & Marquard, 1993; Montague & Bos, 1986), it was clear that more authentic implementation (i.e., in general education inclusive math classes taught by math teachers) and a more stringent research design (i.e., a randomized experimental design) were necessary to determine its effectiveness. A federally funded efficacy and replication project (2007–2010) was conducted in a large, urban school district to test the effectiveness of the intervention in middle school math classes that included students with LD.

Intervention

The intervention used in the MSM Project is based on the components of cognitive strategy instruction and teaches students to effectively, efficiently, and flexibly solve math word problems. The intervention was designed originally to improve the math problem-solving skills of students with LD in middle and secondary schools (Montague, 1992; Montague & Applegate, 1993; Montague & Bos, 1986). Characteristically, these students have processing difficulties, limited metacognitive strategies, poor problem representation strategies, and low motivation and self-efficacy. The central idea underlying strategy instruction is to explicitly teach the cognitive processes utilized by proficient learners during a challenging task to less proficient learners through instruction that emphasizes metacognitive skills and incorporates process modeling, scaffolding, and mastery learning. In this problem-solving intervention, students work with math word problems that vary by operation, number of steps, irrelevant information, and context, and learn to flexibly apply seven cognitive processes (read, paraphrase, visualize, hypothesize, estimate, compute, check) and three metacognitive strategies (self-instruct, self-question, self-monitor; Montague, 2003).

Procedure across Years

The MSM project spanned 3 years. The first year was the pilot study in which both seventh and eighth grade classrooms were included; four teachers participated in each grade. In the second year, 24 eighth grade teachers participated, and then in the final year, 34 seventh grade teachers participated. In years 2 and 3, each teacher was from a different school in the district. Table 1 displays teacher demographic data across the 3 years. In order to meet eligibility criteria, each teacher was required to teach at least two classes that included average-achieving students, low-achieving students, and/or students with LD. Because the intervention was conducted in a large urban school district in the southeastern United States, the ethnic diversity of the student participants sample was high (and stable) across the 3 years of the study: about 8 percent White, 61 percent Hispanic, 30 percent Black, and 1 percent Other (e.g., Asian, Native American).

In the first year, intervention teachers were provided with one and one-half days of PD during the summer, which focused on introducing teachers to the instructional materials (including scripted lessons, class charts, student cue cards, and practice problems), the instructional approach and characteristics of the intervention, as well as practical considerations of intervention research. Lower than expected fidelity of implementation of the intervention (i.e., 42 percent), as

TABLE 1
Teacher Demographic Data across the 3 Years

	Year 1		*Year 2*		*Year 3*	
Variable	*Intervention (n = 4) n (%)*	*Comparison (n = 4) n (%)*	*Intervention (n = 8) n (%)*	*Comparison (n = 16) n (%)*	*Intervention (n = 17) n (%)*	*Comparison (n = 19) n (%)*
Grade						
Seventh	2 (50)	2 (50)			17 (47)	19 (53)
Eighth	2 (50)	2 (50)	8 (33)	16 (67)		
Ethnicity						
Hispanic	1 (25)	1 (25)	2 (25)	10 (62)	11 (65)	8 (42)
Black	1 (25)	2 (50)	4 (50)	3 (19)	4 (25)	8 (42)
White	1 (25)	1 (25)		2 (13)	1 (5)	2 (11)
Other	1 (25)		2 (25)	1 (6)	1 (5)	1 (5)
Gender						
Male	2 (50)	1 (25)	3 (38)	4 (25)	10 (59)	5 (26)
Female	2 (50)	3 (75)	5 (62)	12 (75)	7 (41)	14 (74)
Level of education						
Bachelor's	3 (75)	2 (50)	3 (37.5)	9 (56)	9 (53)	9 (48)
Master's	1 (25)	1 (25)	3 (37.5)	6 (38)	6 (35)	8 (42)
Specialist				1 (6)	2 (12)	1 (5)
Missing		1 (25)	2 (25)			1 (5)
Years of teaching						
1–3		1 (25)	1 (12.5)	1 (6)	8 (47)	5 (26)
4–9	2 (50)	2 (50)	4 (50)	6 (38)	3 (18)	2 (11)
10 or more	2 (50)	1 (25)	1 (12.5)	9 (56)	6 (35)	12 (63)
Missing			2 (25)			

measured by a fidelity checklist during observation, led to an increase in training for teachers in years 2 and 3; 3 full days of PD were instituted, resulting in a subsequent significant increase in fidelity (87 percent and 95 percent, respectively). The added day and a half allowed for substantially more time dedicated to teacher modeling practice and feedback. Furthermore, extended time was spent on modeling the four lessons and discussing the underlying instructional approach.

Across the 3 years of the study, teachers were required to set aside 3 consecutive days early in the fall semester to introduce the routine, establish student mastery of the acronym (i.e., RPV-HECC for Read, Paraphrase, Visualize, Hypothesize, Estimate, Compute, Check), provide process modeling, and finally support students as they solve word problems in groups and individually using the routine. Following the 3-day intervention were weekly practice sessions in which students solved word problems using the routine; lesson scripts both for practice sessions and the 3-day intervention were provided. Trained graduate assistants observed lessons throughout the school year to measure treatment fidelity. They also provided minimal support to teachers during the lesson (e.g., handed out cue cards, collected student work, provided feedback on lesson quality). To measure student growth in math problem solving, curriculum-based measures (CBMs) were administered to each intervention teacher's participating classes six times (i.e., monthly) over the course of each year, and three times to each comparison teacher's participating classes. The "missing" data for the comparison students were built into the study design as a means of reducing excessive testing, seeing as these students were not receiving treatment or performance feedback. Students in the comparison condition were thus tested every other month as opposed to monthly.

The core of the intervention rests on the instructional content (i.e., the seven cognitive processes and three metacognitive strategies) and the instructional approach (i.e., explicit instruction). Thus, to ensure that the intervention components were implemented appropriately, treatment fidelity was measured across the 3 study years using four researcher-developed checklists corresponding to each of the four lessons of the intervention (one for each of the 3-day intervention and one for all subsequent weekly practice sessions). Each checklist reflects the critical components necessary to successful planning and implementation of the lesson to which it is aligned (Cordray & Pion, 2006). The checklists were developed based on the conceptual framework of Carroll et al. (2006), addressing adherence, dose, quality of delivery, participant responsiveness, and program differentiation. The critical components were scored as "yes" or "no." (See Figure 1 for the observation checklist used in lesson 3.) Graduate assistants observed all three initial instructional sessions for each teacher as well as each of the weekly practice sessions. In year 1, treatment fidelity across all treatment teachers was 42 percent and interrater agreement was 90.8 percent; in year 2, treatment fidelity across treatment teachers was 87 percent (range = 69–98 percent) and interrater agreement was 98 percent; in year 3, treatment fidelity across treatment teachers was 95 percent (range = 77–100 percent) and interrater agreement was 99 percent.

Lesson 3: *Solve It!* Observation Checklist - Strategy Mastery Check and Practice

Teacher: ________________________ School: ____________________ Grade Level: _____ Period: _____

Date of Observation: __________Time of Observation: _______ Observer/Partner GA: ______________________

***SOLVE IT!* – Lesson 3**

Check the appropriate box for each instructional component: YES = behavior observed; NO = behavior not observed

Preparation

Did the teacher:	Coding	Notes
Have student copies of the problems?	Y N	
Display Master Charts?	Y N	
Distribute student folders?	Y N	
Distribute cue cards?	Y N	

Implementation

Did the teacher:	Coding	Notes
Check students' RPV-HECC mastery?	Y N	
Check that all students met 100% mastery criterion and reinforce students by checking the Star Chart?	Y N	
Model the process using process modeling by: Reading the problem? Paraphrasing? Visualizing (emphasizing relationships among problem parts)? Hypothesizing? Estimating? Computing? Checking?	 Y N Y N Y N Y N Y N Y N Y N	
Use the group problem solving routine?	Y N	
Prompt students during student modeling?	Y N	
Provide strategy rehearsal practice?	Y N	
Provide positive and corrective feedback?	Y N	

Notes:

FIGURE 1 Fidelity observation checklist for lesson 3.

As described above, the PD in years 2 and 3 included a substantial increase in the time dedicated to teacher practice, where each teacher modeled a lesson to the workshop "class" of peers and researchers while his/her peers evaluated the lesson using the aligned fidelity checklist. This structure allowed both the model teacher and his/her peers to identify specific components of the lesson and ensure that they were included accurately. During the PD, this activity for lesson 3 (which focused on strategy mastery and practice) ran as follows: the lead researcher described the instructional content and approach of the lesson, and then one teacher stood at the front and modeled the scripted lesson, which for this particular lesson included problems for the teacher to model and then the students to solve. The other observing teachers used the fidelity check (see Figure 1 above) to assess whether each of the critical behaviors of the lesson was addressed. The scripted nature of the lesson meant that, as long as the script was followed, teachers accurately covered its content. For the components of the instructional approach (e.g., "Did the teacher: Model problem solving by visualizing, emphasizing the relationships among problem parts? Prompt students during student modeling? Provide positive and corrective feedback?"), however, more onus was on the teachers to incorporate those features into the lesson. This modeling activity with peer observation provided teachers a chance to actively and collaboratively engage with the lesson content and instructional approach through the fidelity checklist.

Once the intervention began with teachers implementing the lessons in their classrooms, graduate assistants observed the lessons with the same fidelity checks used by teachers in the PD. If any of the components of the checklist were not met in the observed lesson, the teacher and graduate assistant met briefly to discuss it. When a teacher repeatedly struggled to fulfill a particular component effectively despite feedback, the lead researcher took over the subsequent practice session to model instruction while the teacher observed. The lead researcher provided between zero and three modeling sessions per teacher over the course of each study year. Consistently, teacher instruction following the researcher model returned fidelity to acceptable levels.

Research Findings

The results of the first year of the MSM project (Montague et al., 2009) with students in grades seven and eight indicated that average-achieving students, as well as low-achieving students and students with LD who received the intervention ($n = 185$), made significantly greater progress in math problem solving over the school year than students in the comparison group ($n = 127$) as measured by CBMs of textbook-type problems ($g = .44$). They also made significantly greater growth in math problem-solving self-efficacy and math confidence over the school year than students in the comparison group ($g = .37$). As expected, students in grade eight had higher scores initially than grade seven students. However, the rate of growth was the same for both grades. In the second year (Montague, Enders, & Dietz, 2011), 24 middle schools (matched on performance level and socioeconomic status) participated. The intervention was implemented for 7 months in general education grade eight math classrooms and periodic progress monitoring was conducted across the school year. The results indicated that students who received the intervention ($n = 319$) showed significantly greater growth in math problem solving over the school year than students in the comparison group ($n = 460$) who received typical classroom instruction ($g = .91$, a large effect). The intervention had the same impact for students with LD, low-achieving students, and average-achieving students. By the end of the school year, the students with LD significantly outperformed even the average-achieving students in the comparison group. In the third year (Montague, Krawec, Enders, & Dietz, 2013), 34 schools completed the study (16 intervention, 18 comparison). The intervention was embedded in the district curriculum in grade seven math classrooms. The same design was used and, again, results indicated that the intervention group ($n = 644$) showed significantly greater growth on CBMs, a measure of math problem-solving self-efficacy, and the math test of the Florida Comprehensive Assessment Test (FCAT) over the school year than the comparison group ($n = 415$) who received only the district curriculum. Although the difference in growth rate between groups on the math test of the FCAT was not statistically significant, a small effect on growth rate from 2009 to 2010 was evident for the intervention group only. Again, the effects did not differ for ability groups. Thus, the research findings have been consistently positive and support the efficacy of this cognitive strategy instructional intervention to improve students' problem solving, including low-achieving students and those with LD, in inclusive math classrooms.

INSTRUCTIONAL IMPLICATIONS AND PROFESSIONAL DEVELOPMENT

The results of the 3-year MSM project clearly support the use of the intervention described above as an effective instructional routine to improve the math problem solving of middle school students of varying abilities. As such, several of the research findings are noteworthy and highlight instructional implications for students with and without LD as well as provide direction for improving teacher training. Each of the four instructional implications included below describes study findings, evidence-based support from the literature, and its role in improving teacher preparation and PD.

Importance of Problem Solving

In the third year of the MSM project, the intervention appeared to have a positive impact on the performance of the intervention students on the state assessment in math. This impact was specifically evident for students with LD and low-achieving students, the lowest performing groups, whose scores improved substantially from 2009 to 2010. Again, although intervention and comparison group differences in growth were not significant statistically, a small effect was found for the intervention group, largely attributable to the increase in scores for the students with LD and the low-achieving students. Most state math assessment reports are global in the sense that they produce a composite score; that is, they do not break out scale scores that would provide insight into performance on various strands of math skills, concepts, and applications tested (e.g., computation, applied problem solving, measurement, geometry). Thus, the results of this study are promising in that they suggest that improved problem solving may have an impact on overall math scores for low-performing students. The NCTM has consistently advocated for problem-solving instruction to be a key component in the mathematics curriculum, in part because of its relevancy to all math content (NCTM, 2000). By incorporating problem solving across the mathematics strands, "students can not only apply the knowledge and skills they have acquired but can also learn new mathematical content" (Mirra, 2009, p. 9).

More recent elementary math textbook content has increased in the quantity of math word problems as well as the cognitive complexity of those problems (Baker et al., 2010); however, other research has found that the corresponding instructional supports which aid teachers in effectively teaching the requisite skills and strategies to solve word problems are insufficient (Van Garderen, Scheuermann, & Jackson, 2012). Thus, while an emphasis on problem solving is feasible because the content is available, the lack of support to carry out that instruction ultimately limits its inclusion in the curriculum. It is critical that PD not only emphasizes the central importance of problem solving but also provides guidance and direction in how to embed it effectively throughout the curriculum so that the knowledge and skills students learn within strands are accurately applied in the real-life context of the word problems. Research by Moyer-Packenham, Bolyard, Oh, and Cerar (2011) corroborates this need at a broader level. The authors analyzed over 2,000 PD activities in the National Science Foundation's Math and Science Partnership Program and found that while the workshops emphasized research-based practices and highlighted important content, they lacked an explicit connection to teachers' classroom practices. Again, the efficacy of an instructional method is irrelevant without the means to implement it effectively and with integrity.

Extended Learning Opportunities

Providing PD for teachers is a critical component of any evidence-based intervention; it is no different for this instructional program. In fact, the general education math teachers in the MSM project expressed both a desire for more PD for teaching students with learning difficulties and a need for ongoing monitoring, feedback, modeling, and coaching that would provide the support necessary for implementing the research-based program as designed. During the first year of the project, only one and one-half days of PD were provided. Based on the fidelity of implementation monitoring, the duration of PD was increased to 3 days, which appeared sufficient for adequate implementation with support. The additional time prior to the start of the intervention provided teachers with more confidence implementing the routine and also increased the likelihood that they remained supportive of and enthusiastic about the intervention as a whole. Additionally, project personnel were available to provide materials and support the teachers as they implemented the intervention over the course of the year. Finally, the principal investigator modeled at least one practice session for each teacher to reinforce fidelity of implementation. These supports were necessary to ensure both integrity of implementation in the context of a research project and that teachers had the expertise to consistently provide the intervention efficaciously. Thus, any PD required of a new intervention should be of sufficient duration that teachers feel confident to implement it as it was designed.

Sufficient duration of PD is a critical characteristic of effectiveness (Blank et al., 2007). Other research has established that about 50 hours of PD is optimal to bring about sustained change in performance (Darling-Hammond et al., 2009); less time in PD and/or an absence of follow-up sessions will likely result in a fading of the new instructional method. Cohen (1990) provided a case study of one teacher's self-described successful implementation of reform-based mathematics into her classroom. She believed that she had eliminated her traditional teaching methodology and embraced the new curriculum, both in content and in process. Cohen's observations of classroom practice, however, revealed a muddled version of both, because "as teachers and students try to find their way from familiar practices to new ones, they cobble new ideas onto familiar practices . . . Changes that seem large to teachers who are in the midst of struggles to accommodate new ideas often seem modest or invisible to observers who scan practice for evidence that new policies have been implemented" (p. 312). Time spent in PD, it seems, is the most effective tool to guard against what Cohen terms "a remarkable mélange" (p. 311). PD must be designed in such a way as to allow teachers sufficient time to understand the content and the parameters of its use and also to master the teaching strategies required to implement the content as intended.

Interventions and State Standards

The teachers in the MSM study noted the pressures associated with adhering to the district curriculum and preparing students for the state assessment. These concerns are relevant and important because teachers may not implement an instructional program, regardless of its evidence base, if they view it as an addition or supplement to the curriculum or perceive it as an added burden to their primary teaching responsibilities. For these reasons, the problem-solving intervention was embedded into the curriculum to the extent possible by limiting initial instruction to only 3 consecutive days of intensive instruction and then using problems drawn directly from the district curriculum for the practice sessions. All practice problems that were conducive to the application of the problem-solving routine were identified, linked to the appropriate state standard, and represented visually. Based on their classroom resources, the teachers could use either an overhead projector or SmartBoard for modeling the problem solutions during practice sessions. Teacher feedback from years 2 and 3 (where problems were aligned to pacing guide standards) compared to that of year 1 (where problems were provided arbitrarily) was significantly more positive. Since they were provided curriculum-relevant materials, most teachers perceived the intervention as complementary and embedded rather than as supplementary and, thus, were willing to implement the intervention as intended.

Especially in this age of teacher accountability in regard to student outcomes, teacher training must inform teachers of *what* methods/programs successfully impact performance as well as *how* to effectively embed those methods into their curricula. Beyond the importance of PD programs emphasizing content (i.e., the *what*), Garet, Porter, Desimone, Birman, & Yoon (2001) identified active learning, which allows teachers opportunities for hands-on work with the new method/program: "Activities that are linked to teachers' other experiences [and] aligned to other reform efforts . . . appear to support change in teaching practice, even after the effects of enhanced knowledge and skills are taken into account" (Garet et al., 2001, p. 936). There are many instructional interventions, in math and other areas, which have been proven effective in a research setting. But, effectiveness in a controlled setting free of district/state-mandated programs, testing, and policies may not translate to effectiveness in actual classrooms. Implementation of the intervention by teachers during the MSM project made this fact clear; by aligning it to the mandated curricula, we were able to increase teacher buy-in, which resulted in higher implementation fidelity for the study and significantly greater student performance on both CBMs of problem solving and state assessments of comprehensive math skills. Thus, PD that addresses the frequent research-to-practice gap and provides helpful tools for teachers to synthesize research-based interventions into their curricula is critical to support teachers' use of best practices in their classrooms.

Explicit Instruction

The final recommendation has to do with the teaching methodology and type of instruction that comprises this intervention. The general education math teachers involved in the MSM project needed extensive practice in cognitive modeling (also called process modeling), a teaching procedure that is not natural for most math teachers who often use didactic instruction and worked examples as their primary teaching technique. Teachers' partiality to that approach was evident in the observations made in comparison classrooms, where worked examples represented the most frequently used mode of problem-solving instruction. The main issue with teaching problem solving this way is that it underscores the false idea that problem solving is merely the carrying out of predetermined steps without critical thought or planning. Tate and Rousseau (2007) found connections between instruction based on worked examples and limited teacher–student and student–student discourse as well as to instruction that is not centered on students' mathematical thinking and understanding. PD that "prepares teachers to focus on mathematical understandings and reasoning" and focuses on "content, *effective instruction,* and student thinking in the content domain" (p. 1224, emphasis added) can help transform instruction to reflect best practices.

In the MSM project, replacing teachers' initial instructional methods (e.g., worked examples) with effective, research-based strategies was a process. In order to reinforce the use of cognitive modeling in the MSM project, it was emphasized during the PD workshop. Cognitive modeling is a type of thinking aloud in which a teacher allows students to observe his/her thought processes while executing a task (Dole, Nokes, & Drits, 2009). After the PD workshop, the research team modeled the method during problem-solving instruction as needed in the classrooms over the course of the project. Furthermore, at least once during the year, the researcher visited each teacher's classroom to model a practice session using the same scripts provided to teachers. One of the major difficulties teachers experienced with cognitive modeling was with purposely incorporating errors into their think-alouds; thus, time during the PD workshop, as well as the researcher-modeled practice session, was devoted to demonstrating this important component to the method.

One critical feature of our PD, aligned with the research in effective PD (e.g., Blank et al., 2007; Darling-Hammond et al., 2009), was that teachers modeled the routine in front of their peers. More misconceptions were addressed and more questions were asked during this phase of the workshop than throughout the lecture sessions. Garet and colleagues (2001) found that teachers are more likely to try methods that have first been modeled for them; furthermore, "teachers themselves judge PD to be most valuable when it provides opportunities to do 'hands-on' work that builds their knowledge of academic content and how to teach it to their students" (Darling-Hammond et al., 2009, p. 10). Therefore, requiring that teachers actually implement the routine with available support and feedback should increase the fidelity of implementation by bringing to surface and then resolving any misconceptions.

CONCLUSION

Conducting school-based research is a major endeavor not only for researchers but also for administrators and teachers. The logistics of implementing a rigorous and high-quality intervention research study in multiple schools that can contribute to our understanding of what constitutes "evidence-based" instruction are challenging, but those challenges help illuminate gaps between research and practice that might be narrowed through teacher training. The purpose of this article was to describe a large-scale study conducted in inclusive general education math classes to investigate the efficacy of an intervention to improve math problem solving for middle school students with a focus on students with LD. Although the results were positive and promising, several recommendations for implementing this research-based problem-solving intervention were made that may help to facilitate the challenges of linking research to practice; many of the recommendations provided may be applied to other research-based interventions in order to improve their effectiveness and sustainability.

The teachers involved in the MSM project expressed: initial difficulty finding the time to incorporate problem solving as a key feature of the curriculum; a need for sustained support throughout the intervention following the initial 3-day PD; greater confidence in the intervention when it was explicitly aligned with state standards and expectations; and unease with the instructional methodology central to the intervention. These findings are not new to intervention research, and in fact all four issues have been identified throughout the body of research on effective teacher training. It is known that a gap between evidence-based methods and classroom practice exists (Hawley & Valli, 1999; Van Garderen, 2008); PD and teacher education has long been the solution to that issue. However, if we know the characteristics necessary for effective PD/teacher education programs but do not design them in such a way, then we have set our teachers up to fail. In the same way, intervention research must tap into this literature base and design PD that addresses these very issues. Ultimately, the success of an intervention, as with the success of a classroom, lies in the fidelity with which quality instruction is provided; effective PD is the key.

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