Journal of Learning Disabilities

http://ldx.sagepub.com/

A Cognitive Strategy Instruction to Improve Math Calculation for Children With ADHD and LD: A Randomized Controlled Study

Jackie S. Iseman and Jack A. Naglieri

J Learn Disabil 2011 44: 184

DOI: 10.1177/0022219410391190

The online version of this article can be found at:
http://ldx.sagepub.com/content/44/2/184

Published by:

Hammill Institute on Disabilities

and

http://www.sagepublications.com

Hammill Institute on Disabilities

Journal of Learning Disabilities
44(2) 184–195

DOI: 10.1177/0022219410391190
http://journaloflearningdisabilities.sagepub.com
SAGE

A Cognitive Strategy Instruction to Improve Math Calculation for Children With ADHD and LD: A Randomized Controlled Study

Jackie S. Iseman[1] and Jack A. Naglieri[1]

Abstract

The authors examined the effectiveness of cognitive strategy instruction based on PASS (Planning, Attention, Simultaneous, Successive) given by special education teachers to students with ADHD randomly assigned by classroom. Students in the experimental group were exposed to a brief cognitive strategy instruction for 10 days, which was designed to encourage development and application of effective planning for mathematical computation, whereas the comparison group received-standard math instruction. Standardized tests of cognitive processes and math achievement were given at pretest. All students completed math worksheets throughout the experimental phase. Standardized achievement tests (*Woodcock-Johnson Tests of Achievement, Third Edition*, Math Fluency and *Wechsler Individualized Achievement Test, Second Edition*, Numerical Operations) were administered pre- and postintervention, and Math Fluency was also administered at 1 year follow-up. Large pre–post effect sizes were found for students in the experimental group but not the comparison group on math worksheets (0.85 and 0.26), Math Fluency (1.17 and 0.09), and Numerical Operations (0.40 and –0.14, respectively). At 1 year follow-up, the experimental group continued to outperform the comparison group. These findings suggest that students with ADHD evidenced greater improvement in math worksheets, far transfer to standardized tests of math (which measured the skill of generalizing learned strategies to other similar tasks), and continued advantage 1 year later when provided the PASS-based cognitive strategy instruction.

Keywords

ADHD, instruction, intervention, planning, strategies

Attention-deficit/hyperactivity disorder (ADHD) is associated with marked behavioral problems and academic achievement deficits (Todd et al., 2002). Most research has been conducted on the behavioral problems experienced by children who have ADHD, and there are relatively few studies examining academic underachievement (DuPaul & Eckert, 1997). However, children with ADHD have significantly lower academic achievement than their peers as demonstrated by higher likelihood of grade repetition, need for academic tutoring, and enrollment in a special class. Children with ADHD also are more likely to exhibit impairments in reading and academic achievement as well as higher rates of learning disabilities (LD) and school dysfunction (Biederman et al., 1996). As many as 30% to 50% of students with ADHD are retained in their school grade at least once; 25% to 36% never complete high school (Barkley, 2003). In addition, although 35% of individuals without ADHD complete a college program, only 5% of students with ADHD complete college (Menhard, 2007). DuPaul and Eckert (1997) noted that although positive effects have been found for interventions addressing the behavioral difficulties associated with ADHD, the effect sizes for changes in academic performance are typically small. In a review of school-based interventions for children with ADHD, researchers indicated that although teacher interventions are effective in reducing ADHD-related behaviors, they are less effective in enhancing academic performance (Reid, Vasa, Maag, & Wright, 1994). Medication has been found to be helpful in addressing the core behavioral symptoms of ADHD; however, to address noncore symptoms, including academic problems, a multimodal, combined treatment plan has been recommended (MTA Cooperative Group, 2005). There is, therefore, a need for more research on effective and theoretically

[1]George Mason University, Fairfax, VA, USA

Corresponding Author:
Jackie S. Iseman, George Mason University, Department of Psychology, MS 2C6, Fairfax, VA 22030
Email: driseman@gmail.com

driven school-based academic interventions for children with ADHD.

Children with ADHD are characterized as having poor behavioral inhibition (Barkley, 2003). These children also are poor in planning and anticipation; have reduced sensitivity to errors; show impaired verbal problem solving and self-directed speech; have problems developing, using, and monitoring organizational strategies; and demonstrate poor emotional self-regulation (Barkley, 2003). One particularly relevant executive deficit described by Barkley (2003) invoves difficulties with planning ahead, poor problem solving, and struggles to accomplish goal-directed behavior efficiently. Goldberg (2001) described these symptoms as frontal lobe dysfunction resulting in "poor planning and foresight, combined with diminished impulse control and exaggerated affective volatility" (p. 179). Naglieri and Goldstein (2006) suggested that frontal lobe activity, which is part of executive functioning, is consistent with the concept of Planning processing in the Planning, Attention, Simultaneous, and Successive (PASS) theory (Naglieri & Das, 1997b). Researchers using this theory, measured using the *Cognitive Assessment System* (CAS; Naglieri & Das, 1997a), have found that children with ADHD earn average scores on all measures of PASS except Planning (Dehn, 2000; Naglieri, Goldstein, Iseman, & Schwebach, 2003; Naglieri, Salter, & Edwards, 2003; Paolitto, 1999). In addition, Van Luit, Kroesbergen, and Naglieri (2005) also found that Dutch children with ADHD earned their lowest score on Planning as measured by the Dutch version of the CAS. These results tie to Barkley's (1997) view that ADHD involves problems with behavioral inhibition and self-control including deficits in Planning, as described by Naglieri and Das (2005) and operationalized using the CAS. These findings are particularly noteworthy because there is research on the relationship between Planning and academic performance.

Research suggests that cognitive instruction is most effective when the cognitive profiles of children are proficiently matched to related educational interventions (Cormier, Carlson, & Das, 1990; Haddad et al., 2003; Hald, 2000; Kar, Dash, Das, & Carlson, 1992; Naglieri & Gottling, 1995, 1997; Naglieri & Johnson, 2000). A series of research studies has suggested that children who are poor in Planning can be taught to improve in planning behavior. Furthermore, being taught to better use planning strategies when engaged in academic tasks improves their level of performance (Naglieri, 2005). This line of research began with the work of Cormier et al. (1990) and Kar et al. (1992), who taught children to discover the value of strategy use. They demonstrated that children who performed poorly on measures of planning demonstrated significant gains on a nonacademic task when they were taught to utilize strategies. This process allows students to develop efficient cognitive strategies through group discussions without direct instruction from the teacher. Students with a cognitive weakness in planning benefited from this cognitive intervention more than those students who had either another cognitive weakness or no cognitive weakness. This research was extended to academics by Naglieri and Gottling (1995, 1997), who found that learning disabled children's use of strategies could be facilitated, rather than directly taught, resulting in improved performance in math calculation. Those studies were further extended by Naglieri and Johnson (2000), who reported that children with a cognitive weakness in Planning improved considerably over baseline rates in classroom math performance following strategy instruction. Children without a cognitive weakness in Planning also improved, but to a lesser degree. Importantly, similar findings are reported for reading comprehension (Haddad et al., 2003), further suggesting that children who were poor in Planning benefited from an intervention designed to teach them to be more strategic. These investigations involved either typical children or those with LD, but the utility of this planning-based cognitive strategy instruction has not been studied among children with comorbid ADHD and LD. It has also been shown that deficits in memory and strategies can negatively affect mathematics performance, which can cause students to experience difficulties in various of mathematics including conceptualizing mathematical operations, recalling math facts, performing computations, and solving mathematical word problems (Montague, 1996).

The purpose of this study was to examine the effectiveness of a planning-based strategy instruction described by Naglieri (2005) that, according to previous research (Cormier et al., 1990; Haddad et al., 2003; Hald, 2000; Kar et al., 1992; Naglieri & Gottling, 1995, 1997; Naglieri & Johnson, 2000), appears to benefit students who are poor in Planning as measured by the CAS (Naglieri & Das, 1997a). The academic achievement among children with ADHD might be improved with cognitive strategy instruction that recognizes the weaknesses in Planning common among children with ADHD. Given that planning strategy instruction seems to be an effective intervention among children who are poor in Planning and that children with ADHD frequently have deficits in Planning, it is likely that children with ADHD may benefit from this intervention. This approach is predicted to be more effective than a strictly behavioral approach. Without the neuropsychologically based theory of planning, it would be difficult to select specific behaviors to target that improve planning. This study of children diagnosed with ADHD compared the scores of children who received planning strategy instruction to those of children who received regular math instruction. Moreover, the study examined far transfer of learned strategies to other similar tasks by looking at standardized test scores obtained before the intervention, after the intervention, and at 1-year follow-up.

Table 1. Means, Standard Deviations, *N*s, and *d* Ratios for PASS Standard Scores by Group

	Total Sample			Comparison			Experimental			
Variable	*M*	*SD*	*N*	*M*	*SD*	*n*	*M*	*SD*	*n*	*d* Ratio
Planning	88.7	16.3	29	90.1	17.4	15	87.2	15.5	14	0.2
Simultaneous	99.8	16.7	29	96.3	17.4	15	103.4	15.7	14	–0.4
Attention	92.2	15.4	29	91.5	17.5	15	92.9	13.5	14	–0.1
Successive	95.9	16.4	29	92.1	13.6	15	100.1	18.6	14	–0.5
Full Scale	91.7	15.8	29	89.4	14.8	15	94.2	17.1	14	–0.3

Note: *d* Ratio = (X1 − X2) / SQRT [(*n*1 × *SD*12 + *n*2 × *SD*22) / (*n*1 + *n*2)].

Method

Participants

The sample was composed of 29 students with ADHD and LD. This sample was drawn from a larger group of 74 students (29 with the inattentive type, hyperactive-impulsive type, or combined type of ADHD and 45 without ADHD) who had parental consent to be included in the study. Of the students with ADHD, 21 were males and 8 were females. They ranged in age from 10 through 15 years (*M* = 13 years 0 months). The experimental group and comparison group were similar in age (age *M* = 13 years 1 month and 12 years 11 months, respectively). The sample was predominately Caucasian (89.7%, 86.7% in the comparison group, 92.8% in the experimental group) students whose parents were well educated (93.1% were college graduates, 92.8% in the comparison group, 93.3% in the experimental group). Both the comparison and experimental groups' standard scores on the CAS (*M* = 100, *SD* = 15) are provided in Table 1. Based on parent report and confirmed by teacher report, multidisciplinary team reports, and/or school, medical, or psychological records, all 29 participants had a diagnosis of ADHD and LD (65.5% of the sample, including 71.4% of the comparison group and 61.5% of the experimental group, were on medication for attention deficits). All of the students had moderate to severe LD in the areas of reading, mathematics, or writing, and some had an additional diagnosis of depression (17.2%, 14.3% in the comparison, 20.0% in the experimental group) or anxiety disorders (31.0%, 28.6% in the comparison group, 33.3% in the experimental group). Information about other behavioral disorders was not collected. All participants attended a private school for children with learning problems located in a large metropolitan area in the eastern region of the United States. The private school provides innovative educational services as well as psychological and related therapies.

Procedure

A total of 17 classes of five to eight students were randomly assigned by classroom to the experimental or comparison groups. Only the data from students with parental consent were included in the study. The teachers' names and classes were drawn randomly to be included in either the experimental group or the comparison group. Half of the classes were randomly assigned to the experimental group and the other half of the classes were randomly assigned to the comparison group. More than half of the teachers taught two math classes. Those teachers had one of their classes randomly assigned to participate in the experimental condition, and their other class participated in the comparison condition in an attempt to control for teacher effects. In an initial group meeting, all of the teachers in the experimental group were informed about the study and the methods they would use to deliver the planning strategy instruction. This training included didactic instruction (in groups of 3 to 5 teachers), with opportunities to practice implementing the planning strategy instruction through role-playing activities supervised by the first author. In addition, the first author worked closely with each of the teachers to ensure that they performed the planning strategy instruction correctly and were comfortable with the process. She provided feedback to the teachers regarding their accuracy in implementing the method and provided suggestions as needed throughout the study. The first author also observed teachers on the first day of participation in the study and then on a weekly basis to ensure fidelity of treatment and consistency in administration of all measures. Teachers were continuously given feedback throughout the study to ensure treatment fidelity. The first author reported that the teachers displayed average adherence to the treatment model.

During the baseline sessions and prior to the beginning of the intervention phase of the study, the CAS (Naglieri & Das, 1997a) was individually administered to each student in both the experimental group and the comparison group. Students were also administered the *Woodcock–Johnson Tests of Achievement, Third Edition* (WJ-III ACH; Woodcock, McGrew, & Mather, 2001) Math Fluency subtest and the *Wechsler Individual Achievement Test, Second Edition* (WIAT-II; Wechsler, 2001) Numerical Operations subtest. These tests were administered to the students as a group by

Table 2. Schedule for the Experimental Group

13 Blocks													
Each daily block was 30 min and consisted of three 10-min sessions: 10-min math worksheet, 10-min unrelated discussion (baseline phase) or planning facilitation (intervention phase), and 10-min math worksheet													
7 Baseline Sessions							19 Intervention Sessions						
These sessions were delivered in the first 3.5 blocks. In the fourth session, the first 10-min math worksheet was considered a baseline session because it occurred prior to a planning facilitation discussion. In each 30-min block, the students completed mathematics worksheets for 10 min then engaged in unrelated discussion for 10 min, and finally they completed another mathematics worksheet for 10 min.							These session were delivered in the last 9.5 blocks. The last 10-min math worksheet in the fourth block was considered an intervention session because it occurred after the first intervention. In each block, the students completed mathematics worksheets for 10 min, then engaged in a 10-min planning facilitation discussion about the strategies they used that were effective in completing the worksheet, and then completed another mathematics worksheet for 10 min.						
Pre–post tests													
CAS	B1	B3	B5	B7	I2	I4	I6	I8	I10	I12	I14	I16	I18
WJ-III ACH	X	X	X	INT	INT	INT	INT	INT	INT	INT	INT	INT	INT
WIAT-II	B2	B4	B6	I1	I3	I5	I7	I9	I11	I13	I15	I17	I19

Note: CAS = *Cognitive Assessment System*; WJ-III ACH = *Woodcock–Johnson Tests of Achievement, Third Edition*, Math Fluency; WIAT-II = *Wechsler Individualized Achievement Test, Second Edition*, Numerical Operations; B = baseline math worksheet; I = intervention math worksheet; INT = intervention (planning facilitation); X = unrelated discussion.

the students' math teachers prior to the beginning of the intervention phase and then again at the conclusion of the study to assess far transfer. Although these tests are typically administered individually, they were administered as a group using standardized instructions. Two different forms of the WJ-III ACH Math Fluency subtest were randomly administered in the pre- and postintervention conditions. No statistically significant differences were present between the experimental group and the comparison group on Math Fluency or Numerical Operations.

All of the students in both the experimental and comparison groups completed two math worksheets each day in their math classrooms throughout the research study. These worksheets were carefully designed to be consistent with the children's curriculum. The worksheets were generated in Microsoft Excel by programming random number functions with specific ranges, controlling the requirements of the math problems. This method allowed construction of a variety of worksheets of a similar level of difficulty. Examples of the math worksheets are provided in Figure 1. Correlations between average baseline scores on math worksheets and Math Fluency and Numerical Operations pretests were .68 and .57, respectively.

Measures

The CAS (Naglieri & Das, 1997a) is an individually administered measure of intelligence based on PASS theory. It is standardized for children aged 5 through 17 years. The CAS is organized according to PASS theory into four scales consisting of PASS processing. Extensive reliability and validity research is presented in the CAS *Interpretive Handbook* (Naglieri & Das, 1997b) and in Naglieri (1999). The Planning scale used in this study includes two subtests: Matching Numbers and Planned Connections. Planning is a cognitive process by which the individual determines, selects, and uses a strategy or method to efficiently solve a problem. The Attention scale used in this study includes the Expressive Attention and Number Detection subtests. Attention is a cognitive process by which the individual selectively attends to a particular stimulus and inhibits attending to competing stimuli. The Simultaneous scale used in this study consists of the subtests Nonverbal Matrices and Verbal Spatial Relations. It involves the ability to integrate various individual stimuli into one whole and to understand logical relationships. The Successive scale contains the subtests Word Series and Sentence Repetition. It involves working with stimuli in a particular sequential order. The intervention in this study is based on the Planning cognitive process and was particularly developed to assist students with poor Planning. The CAS is intended to guide educational interventions, such as planning facilitation, utilized in this study.

The WJ-III ACH (Woodcock et al., 2001) Math Fluency test requires a student to solve simple addition, subtraction, and multiplication problems rapidly. Students are presented with a series of simple arithmetic problems in a subject response booklet. The test has a 3-min time limit. Reliability and validity research is presented in the WJ-III *Technical Manual* (McGrew & Woodcock, 2001).

The WIAT-II Numerical Operations subtest requires a student to solve written calculation problems and simple equations involving the basic mathematical operations, including addition, subtraction, multiplication, and division. The test includes 54 problems, but several of these problems

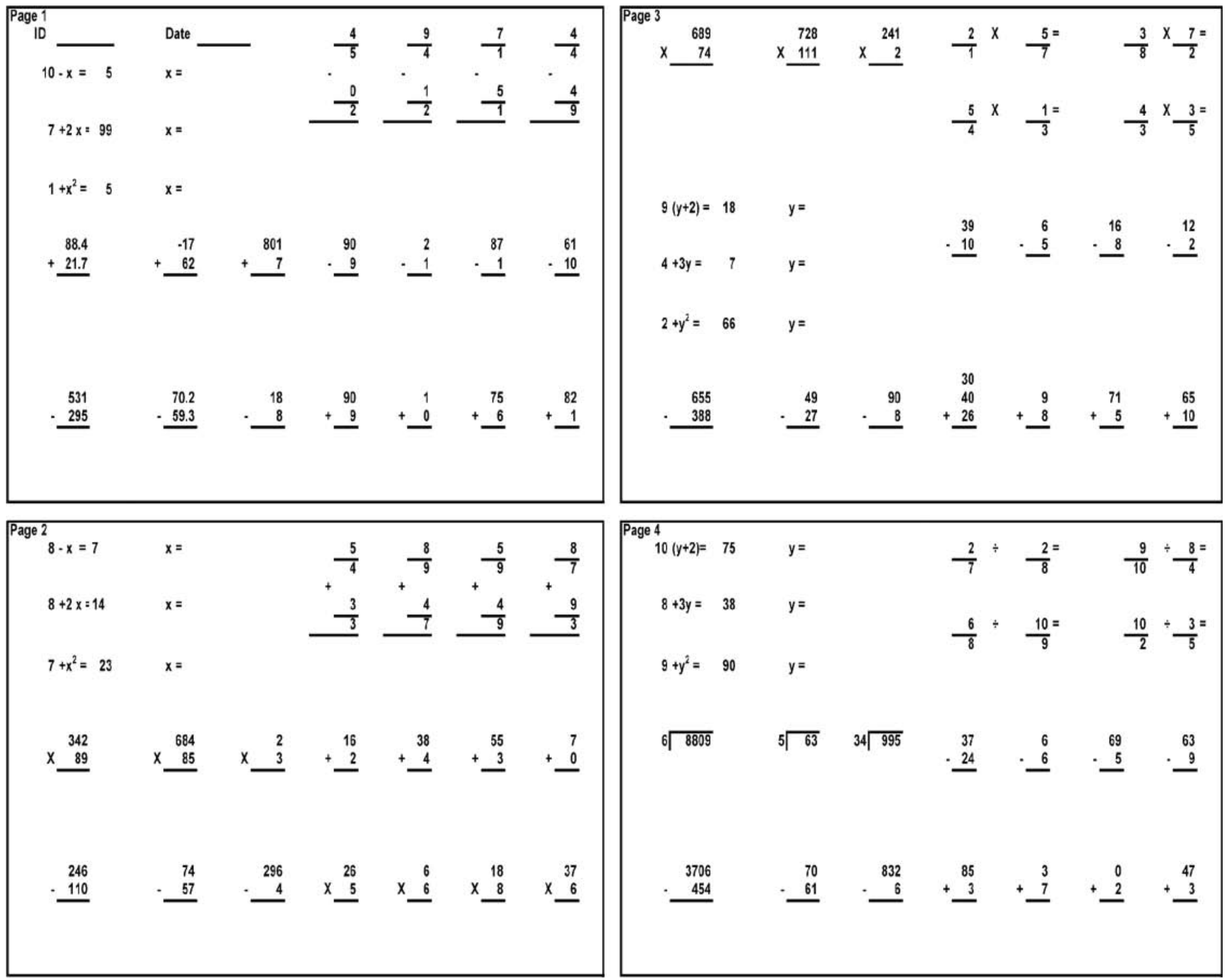

Figure 1. Classroom worksheets

Table 3. Students' Comments During Planning Facilitation Sessions

Goals
- "My goal was to do all of the easy problems on every page first, then do the others."
- "To get as many correct as I can."
- "To get as many right as quickly as possible."
- "To take time and make sure I get them correct."

Starting place
- "I started on the first one."
- "I skipped around."
- "I do the easy ones first."
- "I look at the type of problem and the number of steps and decide which problems to do first."

Overall plan
- "I did all the easy problems on a page and went onto the next one."
- "I do all the addition first, then the easy minus, and then I move onto the harder ones."
- "I do the problems I know, then I check my work."

Specific strategies
- "I simplify fractions first."
- "Skip the longer multiplication questions."
- "The problems that have lots of steps take more time, so I skip them."
- "I do them [the algebra] by figuring out what I can put in for X to make the problem work."
- "I draw lines so I don't get my columns confused [on the multiplication]."
- "I stopped drawing lines because it slowed me down."
- "If a problem is taking a long time I skip it and come back to it if I have time."
- "I did the ones that take the least time."
- "Remember that anything times 0 is 0."

Noticing patterns in the worksheets
- "I did all the problems in the brain-dead zone first."
- "I started in the middle of the page, the problems on top take longer."
- "Next time I'll skip the hard multiplication at the top of the first page."

are below the level of the students who participated in this study. Thus, students were not asked to complete the first 7 problems, as they pertain to identifying and writing numbers and counting using 1:1 correspondence. Extensive reliability and validity research is presented in the WIAT-II *Examiner's Manual* (Psychological Corporation, 2001).

Experimental group. Students in the experimental group completed 26 worksheets over approximately 3 weeks (2 each school day), including 7 baseline worksheets and 19 intervention worksheets, designed to facilitate discussion of strategies (see Table 2). During the baseline phase, regular mathematics instruction occurred for 10 min between the worksheets. During the intervention phase, planning strategy discussions, known as planning facilitation, occurred for 10 min between the two worksheets. The planning facilitation discussions lasted for a total of 100 min (10 min a day for 10 days). All of the sessions were conducted as a group in students' regular classrooms. At the beginning of each session, the students were instructed to "complete as many problems on the page correctly as possible" on a mathematics worksheet. The teachers did not provide feedback about the strategies that the students used or on the mathematical instructions. In addition, the teachers did not provide information about the number of problems the students completed correctly.

The 10-min group discussions, known as planning facilitation, during the intervention phase were designed to encourage self-reflection. The goal of these sessions was to assist the children in understanding the need for the use of planning and employing effective strategies. In this manner, the children could strengthen their use of planning, self-reflection, verbalizing the methods employed, and self-evaluation. Guidelines for prompting were established following the method outlined by Naglieri and Pickering (2003). The planning facilitation included teacher-led discussions, derived from the belief that planning can be facilitated rather than taught directly. Using probes, the teachers encouraged the children to consider and then verbalize various ways of completing more mathematics problems accurately. Student discussion focused on well-planned and organized strategies to address the specific demands of the math worksheets. The teachers provided probes, including statements such as "Can anyone tell me anything about these problems?" "Let's talk about how you did the work," "What was the same or different about the problems?" "What could you do to make this seem easier?" "Why did you do it that way?" "How did you do the

Table 4. Pre- and Postintervention Scores and Effect Sizes for Math Worksheets and Measures of Far Transfer for Students With ADHD in the Experimental (*n* = 14) and Comparison (*n* = 14) Groups

	Preintervention			Postintervention			
	M	*SD*	*n*	*M*	*SD*	*n*	*d* Ratio
Experimental group							
Math worksheets	29.0	8.6	14	42.7	21.0	14	0.85
WJ-III ACH Math Fluency	60.9	19.3	14	86.1	23.6	14	1.17
WIAT-II Numerical Operations	14.4	5.1	14	16.6	5.6	14	0.40
Average effect size							0.81
Comparison group							
Math worksheets	32.8	17.1	14	37.8	21.0	14	0.26
WJ-III ACH Math Fluency	75.5	36.9	13	79.4	43.6	13	0.09
WIAT-II Numerical Operations	15.0	6.4	14	14.0	7.6	14	–0.14
Average effect size							0.07

Note: WJ-III ACH = *Woodcock–Johnson Tests of Achievement, Third Edition*; WIAT-II = *Wechsler Individualized Achievement Test, Second Edition*.
Effect size = (X1 − X2) / SQRT [(*n*1 × *SD*12 + *n*2 × *SD*22)/(*n*1 + *n*2)].

problems?" "What could you have done to get more correct?" "What did it teach you?" and "What will you do next time?" Discussions and further development of ideas followed from the responses of the students. For example, some students shared approaches with classmates including drawing columns in the multiplication problems to keep the answers more organized, and other students discussed strategies such as simplifying fractions before performing addition, subtraction, multiplication, or division (see Table 3). The teachers reinforced that the students believed these strategies were helpful, asked classmates for feedback, and led a discussion about other strategies students used to make the problems easier or get more problems correct (see Figure 2).

Teachers provided some clarification and feedback to the students about the general usefulness of strategies and sometimes posted lists of strategies discussed by the children. However, teachers were instructed to refrain from making comments about specific items on the worksheets, such as "That is correct" or "Remember to use that same strategy." The teachers made statements that were designed to encourage the students to think aloud with the other students about the methods of completing the mathematics worksheets. Thus, the students were encouraged to use strategies to complete as many problems correctly as they could. As the intervention progressed, students frequently employed strategies recently discussed by classmates and also used their own effective strategies more often, resulting in both greater accuracy and efficiency of problem completion on the worksheets.

Comparison group. Students in the comparison group received their typical mathematics instruction. They completed the same mathematics worksheets as students in the intervention group and were given the same instructions at the beginning of the study and on each math worksheet; however, they did not participate in the intervention discussion sessions. Instead, the comparison group received 10 min of instruction in accordance with their normal mathematical instruction. This normal mathematics instruction differed based on the teacher but was based on teachers' current mathematics curriculum. The instruction focused on subjects related to the mathematics worksheets, as the problems on the mathematics worksheets were drawn from the students' curriculum; however, it did not discuss the math worksheets directly. All of the sessions were conducted with the students included in the study as a group in their regular classrooms.

Data Analysis

Scores for the mathematics worksheets were obtained by computing an average baseline score (7 worksheets) and an average intervention score (19 worksheets) for each student. The averages were used to increase reliability in comparison to individual worksheets, which would have lower reliability. The impact of the planning facilitation was expected to occur over time, so the goal was to look at the entire preintervention period in comparison to the entire postintervention period. Raw scores on the WJ-III ACH Math Fluency test and the WIAT-II Numerical Operations test were used to determine how well students were able to transfer strategies learned from the math worksheets to other measures of mathematics. Standard scores were not used as the administration was nonstandardized (group administration, no baseline or ceiling was used, and the starting point differed from standardized administration). These measures of far transfer, which measured students' skill at generalizing learned strategies to other similar tasks, were administered to each

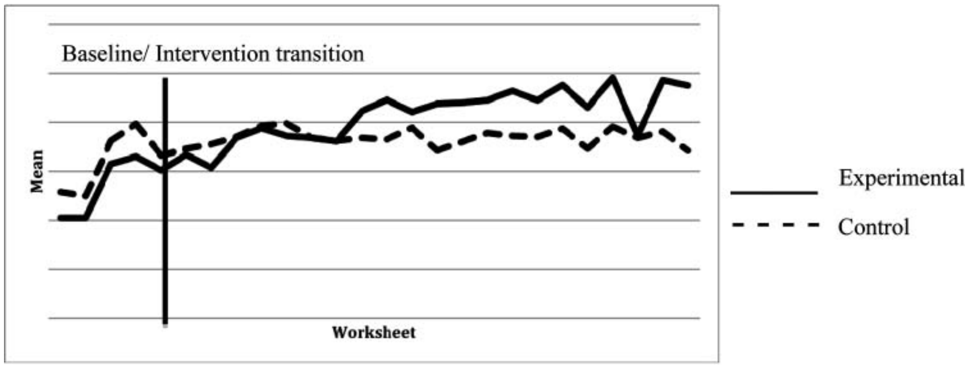

Figure 2. Mean worksheet score for students in the experimental and comparison groups during baseline and intervention sessions

student as a class by the teacher prior to and at the completion of the 26 worksheets. Finally, the WJ-III ACH standardized achievement test was administered individually 1 year after the completion of the study. Group effect sizes were computed according to Cohen's *d*. An effect size of 0.2 was considered small, 0.5 was medium, and 0.8 was large (Cohen, 1988).

Results

Table 1 provides the PASS means and standard deviations for the total sample and for the experimental and comparison groups. The average CAS Planning score of 88.7 was lower than the average of the Attention, Successive, and Simultaneous processing scores ($M = 95.95$, $SD = 11.18$), and this difference was significant (paired samples t test results were significant), $t(28) = 3.029$, $p < .05$. There were no significant differences between the experimental and comparison groups on the four PASS scales including Planning, Attention, Successive, and Simultaneous processing and the Full Scale, $F(4, 24) = 1.21$, $p > .10$.

Table 4 provides the means, standard deviations, and effect sizes for the experimental and comparison groups on the classroom math worksheets as well as the WJ-III ACH and WIAT-II subtests. Students in the experimental group demonstrated a difference of a large effect size (0.85) between the numbers of problems computed correctly on the math worksheets from preintervention sessions to postintervention sessions, whereas students in the comparison group exhibited a small (0.26) effect size (see Table 4). There were significant treatment effects for the experimental group on each of the three factors examined including performance on the worksheets, WJ-III ACH Math Fluency, and WIAT-II Numerical Operations. Each student's baseline score, pretest score on WJ-III ACH Math Fluency, and pretest score on WIAT-II Numerical Operations were used as covariates, and each student's intervention worksheet score, posttest score on WJ-III ACH Math Fluency, and posttest score on WIAT-II Numerical Operations were dependent variables in a three-factor MANCOVA. The results for the classroom math worksheets indicated a main effect for group. Students in the experimental group improved significantly more than students in the comparison group on all three measures, $F(3, 21) = 3.155$, $p < .05$. There was also a univariate effect for improvement on the worksheets, $F(1, 23) = 7.363$, $p < .05$. These results suggest that students in the experimental group benefited from planning strategy instruction more than the students in the comparison group benefited from standard math instruction and simple practice completing the worksheets. Thus, planning strategy instruction appears to have helped students in the experimental group to develop and use more effective planning strategies to improve their performance on classroom math worksheets.

Analysis of the transfer from classroom math worksheets to standardized tests of math (WJ-III ACH and WIAT-II) yielded important findings. Students in the experimental group also demonstrated significantly greater changes on WJ-III ACH Math Fluency and on WIAT-II Numerical Operations than students in the comparison group. There were significant univariate effects on both of the measures of far transfer. Students in the experimental group improved significantly more than students in the comparison group on WJ-III ACH Math Fluency, $F(1, 23) = 5.542$, $p < .05$, and on WIAT-II Numerical Operations, $F(1, 23) = 8.815$, $p < .01$ (see Table 4). These results indicate not only that students with ADHD benefited from planning strategy instruction in classroom math, as shown by their improvement on the worksheets, but also that they were able to transfer learned strategies to other measures of mathematics, suggesting far transfer of skills.

At 1-year follow-up, 27 of the students were retested on the WJ-III ACH Math Fluency subtest as part of the school's typical yearly evaluation of students. This group included 14 students from the comparison group and 13 students from the experimental group. The results indicated that the improvement of students in the experimental group ($M = 16.08$, $SD = 19$, $d = 0.85$) was significantly greater than the improvement of students in the comparison group ($M = 3.21$, $SD = 18.21$, $d = 0.09$).

Discussion

The goal of this investigation was to extend the work of previous researchers who have found that children in regular education and students with LD who are poor in Planning processing as measured by the CAS improve their academic performance when taught to utilize planning strategies. Importantly, the current results suggest not only that the children with ADHD in the experimental group improved in class worksheets but also that they showed far transfer to standardized math tests and 1 year later were still performing better than the comparison group. Finally, this study further supports researchers who found that children with ADHD perform poorly on the Planning scale of the CAS (Dehn, 2000; Naglieri, Goldstein, et al., 2003; Naglieri, Salter, & Edwards, 2004; Paolitto, 1999; Van Luit et al., 2005). This finding is also consistent with the view that children with ADHD experience a failure of behavioral and cognitive self-control (Barkley, 1997, 2003; Naglieri & Goldstein, 2006).

Over the past decade, researchers have demonstrated the effectiveness of planning strategy instruction (also referred to as planning facilitation) in various academic and nonacademic content areas for students with LD and mild mental retardation (Cormier et al., 1990; Haddad et al., 2003; Hald, 2000; Kar et al., 1992; Naglieri & Gottling, 1995, 1997; Naglieri & Johnson, 2000). Results from this study indicate that children with ADHD also benefited from planning strategy instruction in mathematics.

Developing effective interventions for students with ADHD within an academic setting has been particularly challenging (DuPaul & Eckert, 1997). The effectiveness of the planning strategy instruction with an ADHD sample is particularly notable in light of the struggle that teachers report in working effectively with students with ADHD (Reid et al., 1994). Importantly, previous research has shown small effect sizes at best in school-based interventions for students with ADHD in academic areas (DuPaul & Eckert, 1997, 1998; Reid & Maag, 1998). The findings of immediate far transfer and sustained improvement at 1-year follow-up augment the importance of these results. The finding that planning strategy instruction aided students with ADHD in correct completion of math worksheets is especially important in light of previous research, which includes inconsistent results on the effectiveness of pharmacological treatment on academic performance (Crenshaw, Kavale, Forness, & Reeve, 1999; MTA Cooperative Group, 1999; Pelham & Hinshaw, 1992; Swanson, Cantwell, Lerner, McBurnett, & Hana, 1991). The authors predict that the continued improvement of students in the experimental group was a function of increased use of effective strategies that were gained and maintained from the planning facilitation.

The effectiveness of planning strategy instruction has implications in the fields of education and psychology, particularly for students with ADHD who obtain a low Planning score on the CAS. Planning strategy instruction is not difficult to implement in the classroom. This method yields substantial results in a short period of time. Although this study was conducted over approximately 3 weeks, the amount of time spent actually engaging in planning strategy instruction in this study was 100 min (10 min devoted specifically to planning strategy instruction on each of 10 days). This study showed that planning strategy instruction can be delivered in 10-min sessions integrated within the curriculum in a specific academic content area. Although most of the research on the effectiveness of planning strategy instruction is in the area of mathematics, there is evidence that this method can also be applied to reading comprehension (Haddad et al., 2003).

Limitations

The primary limitation of this study was the number of students in each group. Although the experimental and comparison groups were randomly assigned by class, the total sample size was modest ($N = 29$). In addition, for practical reasons, classes, rather than individuals, were randomly assigned to groups. This method of group selection could pose a limitation because of selection criteria originally used to determine class groupings. In addition, more information about the medications that students were prescribed would have been helpful. Future research should examine the impact of medication because it is possible that taking medication addresses some similar difficulties to the intervention and may weaken the results calculated from the pre–post difference. More details about the specific methods used to identify these children with ADHD as well as external verification of the diagnosis would have allowed for greater generalization of the results. However, even among this relatively small study of 14 students in the experimental group and 15 students in the comparison group, the effectiveness of the intervention was apparent. Replication of this study, therefore, would be beneficial to further explore the utility of planning strategy instruction for larger samples of children with ADHD. The authors also recognize that the approach used in this study affords the strength of the natural grouping of the classes but also the weakness of nonindividualized random assignment as the whole classes were randomly assigned to conditions. An additional limitation of this study was that we analyzed the effectiveness of the intervention in only one content area, mathematics.

Future Research

Future research should compare strategy approaches and examine the interaction of these approaches with comorbidity and medication issues. In addition, because the planning strategy instruction method used in this study does not explicitly teach strategies for math, it will also be important to compare the method to other more direct strategy instruction methods such as the MASTER program (Van Luit & Naglieri, 1999). It would be important to examine the effectiveness of this intervention in other content areas involving planning among students with ADHD and other learning problems. Future studies should also examine the likelihood that a student receiving planning strategy instruction in one content area will generalize the learned strategies to other content areas. Pressley and Woloshyn (1995) recommend that teachers help students apply strategies learned in one subject to various different curriculum areas. They also suggest that the more opportunities a student has to practice using a particular strategy, the more capable the student will become using the strategy broadly in situations beyond the ones in which it was taught. Researchers should also determine whether planning strategy instruction can be useful for improving interpersonal relationships, especially for children with ADHD. Aberson and Shure's (2007) interpersonal cognitive problem solving model described by Spivack, Platt, and Shure (1976) may have particular relevance for children with ADHD who have a deficit in Planning as conceptualized by Naglieri and Goldstein (2006).

Researchers should also examine how the length of time students receive planning strategy instruction may affect effectiveness. Previous designs have included half-hour blocks two to three times per week for 8 weeks (Naglieri & Gottling, 1997), over a 3-month period (Naglieri & Johnson, 2000), and twice a week for 15 weeks (Kroesbergen, Van Luit, & Naglieri, 2003). The results from the current study suggest that a period of 10 min per day on 10 consecutive school days provides sufficient time for students to benefit from planning strategy instruction. Similarly, research is needed to determine whether the sequence of 10 min of working on the academic task followed by 10 min of planning strategy instruction and then 10 min more of the academic task is the best way to deliver the instruction. In addition, utilizing the Math Reasoning cluster from the *Woodcock–Johnson* as a dependent variable may yield the greatest improvement from pre- to postintervention. The benefits of dispersing planning strategy instruction into the curriculum rather than presenting planning strategy instruction as a separate activity should also be examined. This approach has been successfully used in Ashman and Conway's (1993) process-based instruction method, which encourages teachers to integrate plan development into regular classroom practice. These and other areas of research seem warranted given the accumulation of findings about this PASS processing-based cognitive strategy method.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interests with respect to the authorship and/or publication of this article.

Financial Disclosure/Funding

The authors received no financial support for the research and/or authorship of this article.

References

Aberson, B., & Shure, M. B. (2007). Social problem-solving intervention can help children with ADHD. *Journal of Attention Disorders*, *11*(4), 4–7.

Ashman, A. F., & Conway, R. N. F. (1993). *Using cognitive methods in the classroom.* New York, NY: Routledge.

Barkley, R. A. (1997). Behavioral inhibition, sustained attention, and executive functions: Constructing a unifying theory of ADHD. *Psychological Bulletin*, *121*, 65–94.

Barkley, R. A. (2003). Attention-deficit/hyperactivity disorder. In E. J. Mash & R. A. Barkley (Eds.), *Child psychopathology* (2nd ed., pp. 75–143). New York, NY: Guilford.

Biederman, J., Faraone, S., Milberger, S., Guite, J., Mick, E., Chen, L., . . . Perrin, J. (1996). A prospective 4-year follow-up of attention deficit hyperactivity and related disorders. *Archives of General Psychiatry*, *53*, 437–446.

Cohen, J. (1988). Statistical power analysis for the behavioral sciences (2nd ed.). New Jersey: Lawrence Erlbaum.

Cormier, P., Carlson, J. S., & Das, J. P. (1990). Planning ability and cognitive performance: The compensatory effects of a dynamic assessment approach. *Learning and Individual Differences*, *2*, 437–449.

Crenshaw, T. M., Kavale, K. A., Forness, S. R., & Reeve, R. E. (1999). Attention deficit hyperactivity disorder and efficacy of stimulant medication: Meta-analysis. *Advances in Learning and Behavioral Disabilities*, *13*, 135–165.

Dehn, M. J. (2000, October). *Cognitive Assessment System performance of ADHD children*. Paper presented at the annual National Association of School Psychologists meeting, New Orleans, LA.

DuPaul, G. J., & Eckert, T. L. (1997). The effects of school-based intervention for attention deficit hyperactivity disorder: A meta-analysis. *School Psychology Review*, *26*, 5–27.

DuPaul, G. J., & Eckert, T. L. (1998). Academic interventions for students with attention-deficit/hyperactivity disorder: A review of the literature. *Reading and Writing Quarterly: Overcoming Learning Disabilities*, *14*, 59–82.

Goldberg, E. (2001). *The executive brain: Frontal lobes and the civilized mind.* New York, NY: Oxford University Press.

Haddad, F. A., Garcia, Y. E., Naglieri, J. A., Grimditch, M., McAndrews, A., & Eubanks, J. (2003). Planning strategy instruction and reading comprehension: Instructional relevance of the PASS theory. *Journal of Psychoeducational Assessment*, *21*, 282–289.

Hald, M. E. (2000). A PASS cognitive processes intervention study in mathematics. *Dissertation Abstracts International*, *61*, 6-A.

Kar, B. C., Dash, U. N., Das, J. P., & Carlson, J. S. (1992). Two experiments on the dynamic assessment of planning. *Learning and Individual Differences*, *5*, 13–29.

Kroesbergen, E. H., Van Luit, J. E. H., & Naglieri, J. A. (2003). Mathematical learning difficulties and PASS cognitive processes. *Journal of Learning Disabilities*, *36*, 574–582.

McGrew, K. S., & Woodcock, R. W. (2001). *WJ-III technical manual.* Itasca, IL: Riverside.

Menhard, F. R. (2007). *The facts about Ritalin*. New York, NY: Marshall Cavendish Benchmark.

Montague, M. (1996). Assessing mathematical problem solving. *Learning Disabilities Research and Practice, 11*, 228-238.

MTA Cooperative Group. (1999). A 14-month randomized clinical trial of treatment strategies for attention-deficit/hyperactivity disorder. *Archives of General Psychiatry*, *56*, 1073–1086.

Naglieri, J. A. (1999). *Essentials of CAS assessment*. New York, NY: John Wiley.

Naglieri, J. A. (2005). The Cognitive Assessment System. In D. P. Flanagan & P. L. Harrison (Eds.), *Contemporary intellectual assessment* (2nd ed., pp. 441–460). New York, NY: Guilford.

Naglieri, J. A. (2008). *Naglieri Nonverbal Ability Test—Second edition*. San Antonio, TX: Pearson.

Naglieri, J. A., & Das, J. P. (1997a). *Cognitive Assessment System.* Austin, TX: Pro-Ed.

Naglieri, J. A., & Das, J. P. (1997b). *Cognitive Assessment System interpretive handbook*. Austin, TX: Pro-Ed.

Naglieri, J. A., & Das, J. P. (2005). Planning, Attention, Simultaneous, Successive (PASS) theory: A revision of the concept of intelligence. In D. P. Flanagan & P. L. Harrison (Eds.), *Contemporary intellectual assessment: Theories*, *tests*, *and issues* (pp. 120–135). New York, NY: Guilford.

Naglieri, J. A., & Goldstein, S. (2006). The role of intellectual processes in the DSM-V diagnosis of ADHD. *Journal of Attention Disorders*, *10*(1), 3–8.

Naglieri, J. A., Goldstein, S., Iseman, J. S., & Schwebach, A. (2003). Performance of children with attention deficit hyperactivity disorder and anxiety/depression on the WISC-III and Cognitive Assessment System (CAS). *Journal of Psychoeducational Assessment*, *21*, 32–42.

Naglieri, J. A., & Gottling, S. H. (1995). A study of planning and mathematics instruction for students with learning disabilities. *Psychological Reports*, *76*, 1343–1354.

Naglieri, J. A., & Gottling, S. H. (1997). Mathematics instruction and PASS cognitive processes: An intervention study. *Journal of Learning Disabilities*, *30*, 513–520.

Naglieri, J. A., & Johnson, D. J. (2000). Effectiveness of a cognitive strategy intervention to improve arithmetic computation based on the PASS theory. *Journal of Learning Disabilities*, *33*, 591–597.

Naglieri, J. A., & Pickering, E. B. (2003). *Helping children learn: Intervention handouts for use in school and at home.* Baltimore, MD: Brookes.

Naglieri, J. A., Salter, C. J., & Edwards, G. (2003). *Assessment of ADHD and reading disabilities using the PASS theory and Cognitive Assessment System*. Manuscript submitted for publication.

Naglieri, J. A., Salter, C. J., & Edwards, G. H. (2004). Assessment of ADHD and Reading Disabilities Using the PASS Theory and Cognitive Assessment System. *Journal of Psychoeducational Assessment, 22*, 93-105.

Paolitto, A. W. (1999). Clinical validation of the Cognitive Assessment System with children with ADHD. *ADHD Report*, *7*, 1–5.

Pelham, W. E., & Hinshaw, S. P. (1992). Behavioral intervention for attention-deficit hyperactivity disorder. In S. M. Turner, K. S. Calhoun, & H. E. Adams (Eds.), *Handbook of clinical behavior therapy* (2nd ed., pp. 259–283). New York, NY: John Wiley.

Pressley, M., & Woloshyn, V. (1995). Getting started teaching strategies. In M. Pressley & V. Woloshyn (Eds.), *Cognitive strategy instruction that really improves children's academic performance* (pp. 244–252). Saline, MI: McNaughton & Gunn.

Psychological Corporation. (2001). *WIAT-II examiner's manual.* San Antonio, TX: Author.

Reid, R., & Maag, J. W. (1998). Functional assessment: A method for developing classroom-based accommodations and interventions for children with ADHD. *Reading and Writing Quarterly: Overcoming Learning Disabilities*, *14*, 9–42.

Reid, R., Vasa, S. F., Maag, J. W., & Wright, G. (1994). Who are the children with ADHD? A school-based survey. *Journal of Special Education*, *28*, 117–137.

Spivack, G., Platt, J. J., & Shure, M. B. (1976). *The problem solving approach to adjustment: A guide to research and intervention.* San Francisco, CA: Jossey-Bass.

Swanson, J. M., Cantwell, D., Lerner, M., McBurnett, K., & Hana, G. (1991). Effects of stimulant medication on learning in children with ADHD. *Journal of Learning Disabilities*, *24*, 219–231.

Todd, R. D., Sitdhiraksa, N., Reich, W., Ji, T., Joyner, C., Heath, A. C., & Neuman, R. J. (2002). Discrimination of DSM-IV and latent class attention-deficit/hyperactivity disorder subtypes by educational and cognitive performance in a population-based sample of child and adolescent twins. *Journal of the American Academy of Child and Adolescent Psychiatry*, *41*, 820–828.

Van Luit, J. E. H., Kroesbergen, E. H., & Naglieri, J. A. (2005). Utility of the PASS theory and Cognitive Assessment System for Dutch children with and without ADHD. *Journal of Learning Disabilities*, *38*, 434–439.

Van Luit, J. E., & Naglieri, J. A. (1999). Effectiveness of the MASTER program for teaching special children multiplication and division. *Journal of Learning Disabilities*, *32*, 98–107.

Wechsler, D. (2001). *Wechsler Individual Achievement Test* (2nd ed.). San Antonio, TX: Psychological Corporation.

Woodcock, R. W., McGrew, K. S., & Mather, N. (2001). *Woodcock–Johnson III Tests of Achievement.* Itasca, IL: Riverside.

About the Authors

Jackie S. Iseman PhD, is a licensed psychologist with a private practice in Potomac, MD specializing in psychotherapy, assessment, and consultation with children, adolescents, and families. She is the co-author of School Success for Kids With ADHD and 101 School Success Tools for Students With ADHD.

Jack A. Naglieri, PhD is a Research Professor, University of Virginia, Emeritus Professor of Psychology, George Mason University, and Senior Research Scientist, Devereux Center for Resilient Children. He is the author of numerous psychological tests, books, and research papers and his research interests include test development, intelligence, academic interventions, social-emotional competencies, and learning disabilities.