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Author
Zheng, Ruiwen

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The Effect of PALS on Classroom Behavior and Math Performance of Students with ADHD

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Ruiwen Zheng

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Thesis Committee:
Dr. Austin Johnson, Chairperson
Dr. Cathleen Geraghty
Dr. Wesley Sims

The Thesis of Ruiwen Zheng is approved:

Committee Chairperson

University of California, Riverside

ABSTRACT OF THE THESIS

The Effect of PALS on Classroom Behavior and Math Performance of Students with ADHD

by

Ruiwen Zheng

Master of Arts, Graduate Program in Education
University of California, Riverside, December 2018
Dr. Austin Johnson, Chairperson

Since children with ADHD are commonly faced with academic and classroom behavioral challenges (e.g., DuPaul et al., 2004), it is vital to provide effective interventions and support to these students. Peer-Assisted Learning Strategies (PALS) is a structured, class-wide peer-tutoring program that has been found to have a potentially positive effect on students' reading performance (e.g., phonics; What Works Clearinghouse Report, 2012). Previous research results indicated that PALS Math had positive effects on children/adolescents' performance across performance levels and educational needs (e.g., Fuchs, Fuchs, Phillips, Hamlett, & Karns, 1995). Due to limited evidence supporting the use of PALS Math on students with ADHD and none supporting its effect on classroom engagement, the current study will examine whether the implementation of PALS Math can result in an increase in on-task behavior, a decrease in off-task behavior, and an improvement of math performance among students with ADHD. Both an ABAB design and a multiple baseline design are proposed for the

current study. Further information about procedures, measures, and data analysis plan are provided in this research proposal.

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Introduction

As one of the most common referral concerns at school and clinical settings and as a disorder with very high incidence in childhood (Demaray, Elting, & Schaefer, 2003), Attention-Deficit/Hyperactivity Disorder (ADHD) has received a lot of attention among educators, mental-health-service providers, and researchers. Within the DSM-V (Diagnosis and Statistical Manual of Mental Disorders, Fifth Edition), ADHD is categorized under Neurodevelopmental Disorders, and it is characterized as patterns of inattention and/or hyperactivity-impulsivity that have lasted for at least 6 months; these patterns must have adversely impacted individuals' academic/occupational and social functioning across two or more settings (American Psychiatric Association, 2013). The three patterns of symptoms (i.e., inattention, hyperactivity, and impulsivity) mainly occur among different age groups: the most frequent pattern of ADHD during preschool is hyperactivity, while inattention become the main pattern in elementary schools; adolescents with ADHD demonstrate less hyperactivity but more fidgetiness, restlessness, and impatience (American Psychiatric, Association, 2013).

Studies have found associations between ADHD and low academic achievement (Ehm, Kerner, Gawrilow, Hasselhorn, & Schmiedek, 2016; Polderman, Boomsma, Bartels, Verhulst, & Huizink, 2010), low rates of on-task behaviors and high rates of off-task behaviors (DuPaul et al., 2004), adverse long-term academic and behavioral outcomes (e.g., continuous school problems, high-school dropouts, delinquency, poor literacy; McGee, Prior, Williams, Smart, & Sanson, 2002), substance use (Flory, Malone,

& Lamis, 2011), and low levels of social skills and self-esteem (Shaw-Zirt, Popali-Lehane, Chaplin, & Bergman, 2005). These challenges maintain into adulthood: adults with ADHD have been found to have lower education and income, and higher unemployment, as well as higher rates of conduct, depression, and anxiety problems (Ebejer et al., 2012; Zwaan, 2012). Given these adverse outcomes, it is vital to intervene early and support students with ADHD in order to help them prevent and/or reduce adverse, short-term and long-term effects.

According to Centers for Disease Control and Prevention report in 2005, more than half of the children with a diagnosis of ADHD aged 4-17 years took medication for this disorder. However, it has caused concerns about its side effects and influence on children's long-term outcomes. Due to the concerns associated with ADHD medication, Langberg and Becker (2012) conducted a systematic review of empirical research published between 2000 and 2011 to assess its long-term academic influence on youth with ADHD. The researchers found that despite of the existence of academic improvement elicited by the medication, the magnitude of improvement is small. Moreover, a review of studies on ADHD treatment revealed safety and compliance-to-treatment concerns of the most commonly prescribed medication for ADHD (Methylphenidate; Smith, Waschbusch, Willoughby, & Evans, 2000). Smith et al., found promising effects of highly-structured academic interventions, behavior management programs in classrooms, and family-based interventions. Nevertheless, these treatments had received much less attention in the literature compared with extensive reports on ADHD medication. In conclusion, these reports have called for the caution of using medication to treat ADHD, and the needs for other treatment methods, such as behavior management and academic interventions as school-based interventions.

School-based interventions for students with ADHD

A review of school-based interventions for students with ADHD by DuPaul and Weyandt (2006) concluded that there were three major strategies for this student group: behavioral interventions, academic interventions, and social relationship treatments. Behavioral interventions include contingency approaches (i.e., antecedent-based strategies and consequent-strategies) and self-management strategies. Antecedent-based strategies refer to the manipulation of the events preceding the problem behavior, such as choice-making, task-modification, classroom-rule teaching. Opposite to antecedent-based strategies, consequence-based strategies involve the manipulation of the events occurring immediately after the problem behavior. Examples of consequence-based strategies can be token reinforcement, response cost, and verbal reprimands/redirection. The other type of behavioral intervention is self-management. It is defined as a student-implemented intervention, the goal of which is to either increase positive behavior or reduce problem behavior. For academic interventions, the specific strategies vary. Instruction-modification, peer tutoring, computer-assisted instruction (CAI) are all examples of academic interventions. Moreover, in response to the social impairment of the target student group, social relationship interventions have also been examined in previous research. Because of the objective of this study, social relationship interventions will be not discussed in detail here.

Among school-based interventions to address the challenges faced by students with ADHD, contingency management (e.g., Robinson, Newby, & Ganzell, 1981) and academic interventions or academic skill training (e.g., Langberg, Epstein, Urbanowicz, Simon, & Graham, 2008) have been found to have positive effects on reducing these students' problem behavior or improving their academic outcomes. DuPaul and Eckert (1997) conducted a meta-analysis assessing the effects of school-based interventions on students with ADHD. Their study was based on the 63 studies yielded from search between 1971 and 1995. The results revealed that contingency management and academic interventions were found to be more efficacious on behavioral outcomes than cognitive-behavioral strategies regardless of the types of research designs applied with effect sizes ranging from moderate to large. The utility of school-based interventions has been less supported in the literature in terms of their impact on academic outcomes, with effect sizes ranging from nonsignificant to large, compared with the effect of these interventions on behavioral outcomes. However, this meta-analysis didn't integrate data across different types of research designs.

A follow-up meta-analysis based on DuPaul and Eckert's 1997 meta-analysis was conducted to examine 60 studies published between 1996 and 2010 (DuPaul, Eckert, & Vilardo, 2012). The authors also aimed to overcome the limitation of the 1997 meta-analysis and report behavioral and academic outcomes of different interventions (i.e., contingency management, academic interventions, and cognitive-behavioral interventions) across designs. Researchers found that academic interventions or combined academic and contingency management interventions elicited better academic outcomes, and contingency management and cognitive-behavioral strategies resulted in better behavioral outcomes. These findings differed from the results of the 1997 meta-analysis. Whether school-based interventions can be effective in improving both behavioral and academic outcomes remains a question.

Furthermore, even though contingent management strategies have been supported to have a potential effect on improving behavioral outcomes, both consequence-based and antecedent-based strategies require teachers' time and effort on classroom management during academic instruction. Hence, effective tools and strategies that require less teachers' management effort such as self-management, peer tutoring, and computer-assisted instruction (CAI), should be studied more.

Peer tutoring

Peer tutoring, as an academic intervention, has a significant advantage over many other school-based interventions: it reduces the amount of time and responsibilities teachers spend on classroom management during instruction. It is an efficient tool for students to assist each other and stay on academic activities during class. Previous research has revealed its efficiency on improving academic performance for students with or without disabilities. The results from a meta-analysis done by Cohen, Kulik, and Kulik (1982) showed that tutees outperformed those who were not in a peer-tutoring program with a large effect size. The effect was even larger for structured programs, shorter duration of the intervention, as well as lower level skills were being taught. In addition, tutors also performed better than those who didn't serve as tutors. Both tutors and tutees reported positive attitudes about the learning content. Robinson, Schofield, and Steers-

Wentzell (2005) reviewed the literature, and they also found the effectiveness of cross-age tutoring in improving academic performance (i.e., math) and having positive attitudes towards school among tutees and tutors from various ethnic backgrounds. A review of four peer-tutoring models (i.e., classwide peer tutoring, reciprocal relationship, cross-age matching, and other) conducted by Okilwa and Shelby (2010) found, overall, peer tutoring produced potentially positive effects on the academic performance across content areas (e.g., language art, math, science, and social studies) among students with disabilities in Grades 6 through 12.

PALS. The Fuchs research group at Vanderbilt University designed one of the most popular peer tutoring programs, Peer-Assisted Learning Strategies (PALS). It is intended to be implemented at school settings and be integrated with current existing curriculum in order to improve the academic outcomes of children with or without disabilities (Fuchs, Fuchs, Mathes, & Simmons, 1997). In its reading program (PALS Reading), students tutor each other by reading aloud, listening, and providing feedback in multiple academic tasks. By alternating roles of coach and reader, paired students (i.e., one more-advanced reader and one less-advanced reader) can benefit from teaching others and being provided with feedback. The What Works Clearinghouse reviewed eleven studies focusing on the effectiveness of PALS on reading skills of students in kindergarten through third grade (What Works Clearinghouse Report, 2012). The results suggested that the program generated potentially positive outcomes in alphabetics (i.e., phonological awareness and phonics), no discernible effects on fluency, and mixed effects on comprehension for beginning readers.

PALS Math. Even though PALS has been well documented in terms of its effect on improving reading skills of children, only four peer-reviewed articles have examined the effect of the math version of this program (PALS Math) on academic performance. Additionally, these studies neglected to measure classroom engagement as an outcome for participants. Moreover, even though all four studies included students with disabilities, the outcomes of students with ADHD were not specified. The four peer-reviewed journals and two dissertations will be discussed in the following section.

In the first published study on PALS Math, Fuchs, Fuchs, Phillips, Hamlett, and Karns (1995) examined the effects of PALS Math incorporating curriculum-based measurement on students with different types of learning histories (i.e., average-achieving students, low-achieving students, and low-achieving students with learning disability) in Grades 2-4. In particular, the researchers aimed to investigate the transfer effects of math computation intervention to math concepts and application areas after 23 weeks of treatment. The participants were 20 classroom teachers and their students in Grades 2 to 4 of a southeastern school district. The teachers were randomly assigned into two conditions: PALS and contrast. For the PALS group, paired students worked on math operation skills by applying current comprehensive math curriculum and PALS materials and activities. PALS was implemented twice per week, 25 to 30 minutes for each session. Teachers in the contrast condition used their regular instructional procedures. The results revealed the students who received PALS Math had significantly better outcomes than those who did not within the same group (i.e., average-achieving, low-achieving, low-achieving with learning disabilities) on both acquisition and transfer measures. The researchers suggested that school psychologists could consider using PALS to accommodate diverse needs in general classroom.

To extend the research into a younger population, the Vanderbilt research team conducted a study on kindergarteners' math development (Fuchs, Fuchs, & Karns, 2001). Two hundred and twenty-two students from twenty kindergarten teachers in a southeastern school district participated in the study. The 20 teachers/classrooms were randomly assigned into PALS Math condition and control condition. Students in the PALS condition participated in two, 20-minute intervention per week in place of their regular math activities. Their counterparts followed the same curriculum from school district and received teacher-directed instruction instead of PALS. The overall amount of math instruction time for both groups was the same each week. Results demonstrated that PALS Math resulted in strong positive effects on students with medium-level achievement, low-level achievement, and disabilities, but not for students with high levels of achievement, after 15 weeks.

At a roughly same time period, Fuchs, Fuchs, Yazdian, and Powell, (2002) investigated the efficacy of PALS Math on first graders with different levels of academic performance (high achievement, average achievement, and low achievement. Twenty first-grade teachers in a southeastern school district and their three hundred and twenty-seven students participated in the study. These teachers/classrooms were randomly assigned into the PALS condition and the control condition. Using the same district curriculum and allocating the same amount of time on math instruction, teachers in the PALS condition implemented the intervention three times per week, 30 minutes per session; while teachers in the control condition used the Math Advantage Grade 1 to direct their instruction. After the 16-week intervention, they found that with high implementation accuracy (95%), students in the PALS condition outperformed those in the control condition within the same performance group on the PALS-aligned items of the Stanford Achievement Test, while the two groups had comparable performance on unaligned items, which supported the use of PALS Math. In addition, for students with disabilities (i.e., Speech and Language, ADD, and LD), PALS elicited positive effects on PALS-aligned items and negative effects on unaligned items.

At the secondary level, Calhoon and Fuchs (2003) looked into the math challenges faced by students with disabilities and examined the effectiveness of the combination use of PALS and curriculum-based measurement (CBM) in math performance among high-school students (Grades 9-12) with learning disability in math. Ten self-contained resource classes from a southeastern school district were randomly assigned into the PALS/CBM condition and control condition. The treatment group was provided with PALS Math intervention twice a week, 30 minutes per session; while the control group received regular math instruction by using the Buckle Down on Tennessee Mathematics (1998) workbook. After a 15-week intervention, it was found that students in the treatment group (PALS/CBM) outperformed those who received the regular math curriculum on a computation measure but not on concepts/application or the math portion of the Tennessee Comprehensive Achievement Test (TCAP). In each of these studies, teachers were reported to perceive PALS Math as efficient and feasible.

In addition to the four peer-reviewed articles, two dissertations from the University of Southern Maine also addressed the topic about the effectiveness of PALS Math on academic performance. Kiburis (2012) aimed to assess whether the implementation of PALS math as a supplement to an existing curriculum would improve math performance of seventh graders in general education classrooms. In addition, the researcher attempted to assess the effect of PALS Math on fractions computation and integers computation skills of low-performing students. In this study, the experimental group received PALS Math twice a week, 30 minutes for each session; while the control group received the same amount of time on math instruction but no PALS intervention. After four weeks, the researcher compared students' math performance on M-COMP, researcher-created Fractions-CBM, and researcher-created Integers-CBM before and after the intervention. The results suggested that the experimental group demonstrated more gains on math computation and fractions than the control group; lower-performing students had more weekly ROI than higher-performing students. However, how the researcher assigned students into experimental and control groups was unclear; no effect size data were calculated; and the difference of fractions gains between the two groups was small.

The other dissertation on this topic was from Hugger (2014). Hugger's study intended to investigate the effectiveness of a combined PALS-and-relaxation program on third graders' math achievement and math anxiety. Four third-grade teachers and their students in the Northeast participated in the study. The four classrooms were randomly assigned into four conditions, including one control condition and three treatment condition (i.e., PALS, relaxation, PALS + relaxation). In the control condition, school district core math curriculum (i.e., Investigations) and supplemental activities were implemented during math instruction time. Students in PALS condition followed the intervention to work on math computation twice a week, 30 minutes per session in addition to the core curriculum. In the relaxation condition, students were led to engage in a relaxation breathing technique for 3 to 5 minutes before the 25-minute math activities. Students in the combined condition applied the relaxation techniques once between PALS activities. After a 12-week intervention, no significant difference was noted in math performance growth between the combined condition and three other conditions, even though the improvement of the combined group was the highest among the four conditions. The combined condition didn't provoke a significant influence on math anxiety in comparison to three other groups, either. The audience should be cautious about the fact that students in the treatment conditions had more math instruction time than those in the control condition. In addition, the results didn't support a significant advantage of the combined condition over other conditions.

To sum up, these studies indicated that PALS Math had a potentially positive effect on children's performance across performance levels, with or without disabilities, and this intervention received the acceptance of teachers. However, none of these studies addressed the behavioral-engagement issue. Behavioral engagement is defined as students' participation in academic-related activities during teacher instruction. It includes on-task behavior and off-task behavior. Operational definitions of on-task and off-task behavior are provided in Method section. Fredricks, Blumeneld, Paris (2004) reviewed literature related to the relationships between school engagement and different areas of outcomes. They found that prior research had demonstrated a positive correlation between behavioral engagement and concurrent academic achievement across age groups (e.g., elementary to high school), as well as a negative correlation between behavioral engagement and school dropout. Some studies also found the long-term effect of behavioral engagement on academic achievement. For example, a longitudinal study conducted by Ladd and Dinella (2009) found that engagement during Grades 1-3 predicted children's academic growth for Grades 1-8. Both concurrent and prospective predictions of classroom engagement for academic performance were resulted. The concurrent and long-term relationships found between behavioral engagement and academic outcomes in the literature indicate that it is imperative to improve student behavioral engagement.

As mentioned at the beginning of this article, it has been reported that students with ADHD engage in high levels of off-task behavior and low levels of on-task behavior during instruction; their academic performance also raises concern. Their behavioral and academic deficits call for the need for an effective program to help this student group remediate these deficits and reduce short-term and long-term effects caused by this disorder. A review of literature on PALS Math revealed that there had not been much research to support the use of PALS Math on students with ADHD. A question about whether children with ADHD will benefit from this program in terms of their academic performance and engagement has not been answered. Thus, more studies should be conducted to investigate the effectiveness of PALS Math in engagement, performance, and on the ADHD population.

CWPT. As another peer tutoring program, Classwide Peer Tutoring (CWPT; Delquadri, Greenwood, Whorton, Carta, & Hall, 1986) shares many similarities with PALS. CWPT was also intended to be used to supplement existing curriculum; it requires students to work in pairs and provide feedback to each other on tasks in reciprocal roles. Moreover, the ultimate goal for the program is to enhance academic achievement by increasing opportunities to respond for students and getting students more actively engaged during class. Different from PALS, CWPT has the team-competition component and pairs are randomly matched within team; and it lacks a reinforcement system built in the curriculum. Nevertheless, PALS and CWPT follows the same principle as increasing active engagement rate among students and providing more opportunities for students to respond, and they shared similar features of peer tutoring.

CWPT has been found its effectiveness in increasing academic engagement (DuPaul, Ervin, Hook, & McGoey, 1998; DuPaul & Henningson, 1993; Mortweet, 1999; Greenwood, 1991; Plumer & Stoner, 2005); reducing fidgeting and off-task behavior (DuPaul, Ervin, Hook, & McGoey, 1998; DuPaul & Henningson, 1993); as well as improving academic performance in reading (Simmons, Fuchs, Fuchs, & Hodge, 1994; Veerkamp, Kamps, & Cooper, 2007), spelling (Chun & Winter, 1999; Mallette, Harper, Maheady, & Dempsey, 1991), and math (Hawkins, Musti-Rao, Hughes, Berry, & McGuire, 2009). Furthermore, the study by DuPaul, Ervin, Hook, and McGoey in 1998 was conducted to examine the effects of CWPT on academic engagement, and math and spelling performance among children with ADHD in Grades 1 through 5. And ABAB design was applied to this study and eighteen students received the intervention over 2 school years. The results indicated that the participants significantly increased their active and passive engagement rates, and decreased off-task and fidgets rates. However, the academic performance outcomes differed across participants.

Purpose statement and research questions

The purpose of the study is to investigate the effectiveness of PALS Math on classroom engagement and math performance of students with ADHD. Specific research questions guiding this study include:

1. Can PALS Math reduce off-task behavior and increase classroom engagement of students with ADHD?
2. Will PALS Math enhance math performance of students with ADHD?

Since CWPT and PALS shared key features and the same behavioral principles as increasing active engagement rate among students and providing more opportunities for students to respond, and there have been evidence supporting the use of CWPT on students with ADHD, it is hypothesized that PALS Math is also effective in reducing off-task behavior, increasing classroom engagement, and enhancing math performance of students with ADHD.

Method

Proposed Participants and Settings

Three second-grade students in the same school district in Southern California with a previous diagnosis of ADHD will be the participants for data collection and analysis in the study while their whole classroom will be receiving treatment. First, potential participants will be referred by second-grade classroom teachers based on their math performance and behavioral deficits. Specifically, the results of math benchmark testing at the beginning of the school year must be below the 25^{th} percentile based on national norms and inattention and/or hyperactivity-impulsivity needs to have been observed during class by classroom teachers. Parents of the students being referred by classroom teachers will be contacted and asked about whether the student has been diagnosed with ADHD by a psychiatrist, a clinical psychologist, or a neurologist. Once a diagnosis of ADHD, math deficits, and behavioral challenges are confirmed, the students will be recruited to participate in the research.

Dependent variables and measures

To answer the research questions, three dependent variables are addressed in this study: on-task behavior, off-task behavior, and math performance.

On-task behavior. Direct observations of on-task behavior will be conducted on the participants and peer comparison children during math instruction or PALS intervention. The observers will utilize the Behavioral Observation of Students of Schools (BOSS; Shapiro, 1996) software to collect the behavior data. In BOSS, active engagement time (AET) and passive engagement time (PET) are coded separately via momentary time sampling. That is to say, whether a student is on-task or not is determined at the beginning of each 15-second interval. In addition, a peer's on-task behavior will be collected for every fifth interval for comparison. Both AET and PET will be used to monitor participants' progress on on-task behavior. AET is characterized as “those times when the student is actively attending to the assigned work.” Examples of AET can be the target student writing answers on the worksheet or talking to a peer about class activity during discussion. Non-examples can be talking to a peer about a video game during math instruction or playing with a pencil. PET is defined as “those times when the student is passively attending to assigned work.” Examples of PET are the student’s eyes orienting towards the teacher during teacher’s scaffolding, or eyes orienting towards the assigned materials. Non-examples are eyes orienting toward a peer when the teacher is giving directions, or looking around the classroom during task.

Off-task behavior. Off-task behavior will also be measured through direct observation during math instruction via BOSS software. Off-task motor (OFT-M), verbal (OFT-V), and passive (OFT-P) behaviors are separately coded via partial interval observation (i.e., behavior is marked if it occurs at any time during an interval), and all the three kinds of off-task behavior will be used for progress monitoring. Peers’ off-task behavior will be also measured for every fifth interval for comparison. OFT-M is defined as “any instance of motor activity that are not directly associated with an assigned academic task.” Examples of OFT-M include playing with pencils during math instruction, or throwing paper at peers. Non-examples are writing answers on assigned worksheet, or walking to the teacher to receive his homework feedback. OFT-V refers to “any audible verbalization that are not permitted and/or are not related to an assigned academic task.” Example of OFT-V can be talking to peers or teacher about after-school parties during instruction, or calling out answers without permission. Non-examples include student talking to peers about a math question during group discussion, or answering the teacher's question. OFT-P is defined as "those times when a student is passively not attending to an assigned academic activity for a period of at least 3 consecutive seconds." Examples of OFT-P can be staring out the window, or eyes on a science book during math class. Non-examples are eyes on an assigned academic material, or eyes on the teacher when the teacher is demonstrating computation steps.

Math performance. Participants' math performance will be measured through curriculum-based measurement (CBM). In particular, second-grade AIMSweb Math Computation (M-COMP) will be administered as pre-scores for pairing students and as probes to track students' progress. M-COMP is a brief, standardized measure of math operation skills based on typical curriculum at grades 1 through 8 with national norms for grades 1 to 12. It can be implemented individually, within a small group, or within a large group. M-COMP probes can be used for benchmark testing and progress monitoring. Based on the evaluation of various academic progress monitoring tools conducted by National Center on Intensive Intervention (NCII), both second-grade M-COMP measures have resulted in adequate reliability of performance level score and slope. They are also sensitive to student improvement as a progress monitoring tool and they have convincing evidence on benchmarks. M-COMP will be used at the beginning of the semester as a benchmark tool to determine and compare the math-performance levels of students within the same classroom. Teachers will rank students based on their benchmark results and pair them based on the ranking. For progress monitoring, M-COMP will be administered among the participants in a small group setting at the end of each week throughout the study.

Interrater agreement. Three raters will be trained to use the BOSS software to collect academic engagement data. Two raters will collect data throughout the observations, while the other rater will collect data during 20% of the sessions across each phase and each participant. Before data collection, the three raters will be trained together by an experienced PhD student in school psychology. Specifically, one or two weeks before the implementation of the research, all raters will have a review of data collection methods (i.e., partial interval, whole interval, and momentary time sampling) in BOSS, definitions and examples of target behaviors, basic procedures for observations, and how to use the software on mobile phones. The raters will also practice at the same time after the review through watching six 5-miniute-long training videos and applying the methods. Issues and questions observed during practice will be discussed. Interobserver agreement will be calculated via Cohen's kappa across intervals. Kappa provides interobserver agreement data after correcting for chance. A kappa value of .60 or higher is viewed as acceptable based on What Works Clearinghouse standards (Kratochwill et al., 2010). If the raters reach .60 or higher agreement on the last two videos, it is recognized as mastery and the raters will viewed as ready for the research procedures. If the agreement levels during training were below .60, rules will be restated and another 3 videos will used for practice.

Social validity. Teacher perceptions of PALS efficacy and feasibility will be measured in a similar way as in the study by Fuchs, Fuchs, Yazdian, and Powell (2002): at the end of the last intervention phase, teacher will be provided with 3 questions measured on a Likert-scale. The questions include: (a) Overall, how much did PALS increase the math achievement of your students; (b) how much did PALS improve the social skills of your students; and (c) how easy would PALS be for you to do on your own? The first two questions will be asked separately for the participants and the rest of the class. Response anchors range from 1 (not at all) to 5 (very much). Students' perceptions of the intervention will also be measured through a rating scale. Due to the complexity of using response anchors in Likert scales, a special rating scale is designed to accommodate these second-graders. In the rating scale, students are asked to make a mark on two 10-CM lines to indicate how much they like the intervention and how much they think the intervention helps with their math learning. On the left side of the line is a frowny face, and on the right side of the line is a smiley face. The closer to the smiley face, the more the student likes the intervention or thinks the intervention helps with their math learning. The closer to the frowny face, the least the student likes the intervention or thinks the intervention is helpful.

Independent variable

PALS. Peer-Assisted Learning Strategies is a class-wide peer tutoring program that was developed by Douglas and Lynn Fuchs and their colleagues at Vanderbilt University (Fuchs, Fuchs, Mathes, & Simmons, 1997). PALS has been found to increase academic performance of students with different needs (i.e., low achievement with/without disabilities and average achievement) in the general education classroom across academic disciplines (i.e., reading and math). PALS sessions vary from 20 to 45 minutes, two to four times per week. During peer-tutoring sessions, students across a whole class are paired based on their academic-performance level by the classroom teacher. During the sessions, students will take turns playing the roles of coach (tutor) and tutee and provide feedback to the other person as they work through structured activities that are based on skills for specific grade levels. Classroom teachers have the responsibilities of introducing the program, pairing students, and implementing PALS in the classroom. The intervention is designed to supplement the core curriculum in the school, provide teachers with guidelines on how to introduce activities and engage with students, encourage positive peer interactions, and keep students on task.

Most studies evaluate the effects of this intervention on reading performance (e.g., phonics, fluency, comprehension; Mathes, & Babyak, 2001; McMaster, Fuchs, Fuchs, & Compton, 2005; Stein et al., 2008). Reading activities for Grades 1 through 6 involved in this intervention include Partner Reading with Retell, Paragraph Shrinking, and Prediction Relay (Fuchs, Fuchs, Mathes, & Simmons, 1997). K-PALS (Kindergarten PALS) requires children to engage in activities including What Sound (letter-sound correspondence), Sound Boxes (decoding), Sight Words, and Reading sentences (Stein et al., 2008). High-school PALS uses similar activities as PALS for Grades 2 to 6, but it requires frequent switches between partners, more structured reinforcement system, and reading materials are mainly on expository (Fuchs et al., 2001). In addition to reading, PALS also has programs for math learning in Grades K through 6. PALS Math is typically conducted twice a week, 30 minutes per session, for at least 20 school weeks.

Similar to PALS Reading, PALS Math values the coaching and guiding process between partners, but it also involves a practice process. The coaching process takes 15 to 20 minutes, and practice lasts 5 to 10 minutes. During the time, students teach each other math skills. During practice, students work on their worksheet (with questions related to the coaching process) independently first and then exchange their results and score each other's worksheets. PALS Math consists of two main skill areas: Computation, and Concept and Application. Although PALS Reading has been studied by many research teams and found its effectiveness in improving students' reading performance, PALS Math has received much less attention in the literature. Based on the results from research conducted by the Vanderbilt research team, it was concluded that PALS Math had a potentially positive effect on children's performance across performance levels, with or without disabilities. However, academic engagement and the performance of students with ADHD were not examined in their research. Therefore, this study is intended to address these gaps and investigate the effectiveness of PALS Math in engagement and math performance on students with ADHD.

Training. The three teachers will receive a one-day PALS training workshop led by the researcher before treatment. The researcher will be familiar with the teacher manual and the student manual in advance. The workshop approximately takes three hours. Videos and teacher manuals offered as a part of the intervention by the Fuchs group will be provided to the three teachers during training. Additionally, teachers will learn how to implement PALS Math to meet individual needs of the students during the 3-hour workshop. Research findings and reviews of math concepts for second-grade PALS Math will also be provided, as well as practice opportunities for all PALS activities. After the training, the three teachers will know how to pair students and guide them during coaching and practice process.

Treatment integrity. For each intervention phase, teacher and students will be observed by the researcher 10% of the time while PALS Math is being implemented. Each observation will last throughout the session (i.e., 30 minutes) to collect treatment integrity data (Fuchs, Fuchs, Yazdian, & Powell, 2002; Fuchs, Fuchs, & Karns, 2001). The PALS Implementation Checklist provided in the manual will be utilized to record whether the intervention features are observed, not observed, or not applicable. The checklist comprises two components: teacher component (e.g., teacher reviews rules) and student component (e.g., students are attentive to the introduction or review of the lesson). Final scores are also separate for teacher and students. Final scores are recorded as total number of checks divided by number of possible checks (i.e., observed plus not observed). The final scores provide information about the percentage of implemented PALS features observed in each classroom.

Procedures

Benchmark testing of math achievement. At the beginning of the semester, the participants' math performance will be measured using M-COMP probes. Teachers will use the results to determine the performance levels of students within the same classroom for ranking and pairing students in PALS treatment.

Baseline. During baseline, the three teachers will follow the school district's core curriculum, typical practice, and the same schedule as before the study. The participants' on-task behavior and off-task behavior during math instruction will be observed and recorded using the BOSS software 20 minutes each time. And their math progress will be monitored using M-COMP at the end of each week. During baseline, two observations will be conducted during math instruction per week. The number of data points collected during baseline will differ based on the research design (see “Research Design” session).

PALS Treatment. Before the intervention starts, the classroom teachers will pair students in the whole class based on their performance from M-COMP benchmark testing. In particular, the whole class is ranked based on students’ test scores. After a median split, the top students from each half will be paired; the next-highest-performing students from each half will be paired, and so on. High performers and low performers are paired to take turns as coach and tutee. Teachers implement PALS Math twice a week, 30 minutes each time, during math instruction. PALS will be used to supplement their ongoing math curriculum. The three participants’ engagement behavior will be measured by observers during PALS Math implementation process for two weeks, 20 minutes each time. And their progress will be monitored by means of M-COMP at the end of each week. Fidelity data will also be collected 10% of each intervention phase, 10 to 15 minutes per time.

For the coaching process during each session, the high performer will play the role of coach (tutor) and the low performer will be the tutee while working on an assigned math worksheet; after 8 to 10 minutes, the roles of the pairs will switch. The coach will provide guidance and feedback to the tutee about their responses on the worksheet. When the tutee writes or speaks a correct answer, the coach will respond by circling the correct answer or giving verbal acknowledgement; when the answer is wrong, the coach will provide help to the tutee about the math problem. The coaching process takes approximately 15 to 20 minutes. For the next 10 minutes (i.e., practice time), students are assigned a mixed-problem worksheet with applications of the same math concepts. Students are asked to work independently on their worksheet. When they finish, student pairs will exchange their worksheets and correct each other's answers.

Research design

Due to the unpredictability of teachers' preference on how they would like to use this program, an ABAB design and a multiple baseline design will both be discussed in this session. The ultimate design will be selected in concert with the teacher.

ABAB design. To implement an ABAB design in this study, the effect of PALS Math will be investigated in the order of Baseline 1, Treatment 1, Baseline 2, and Treatment 2. Baseline 1 will take place for 2.5 weeks. During this time period, the school district's math curriculum and typical class activities will be utilized in the classrooms. The observers will collect on-task and off-task data for 20 minutes on the participants during math instruction. The observation will occur twice per week during math instruction throughout the 2.5-week baseline phase. The classroom teacher will administer M-COMP at the end of each week in order to obtain data for math progress.

Before Treatment 1 starts, the classroom teachers will explain to the whole class about what PALS is, and why and how they will use this program to promote math learning. The teacher will also pair students based on their performance on M-COMP at the beginning of the semester. Specifically, the teacher will rank students according to the math benchmark testing results, do a medium split, and pair the top students from each half, the second-highest students from each half, and so on. The arrangement will change every two weeks. That is to say, students will be re-paired every two weeks. During

PALS, the higher-performing student will serve as the coach first; and the other student takes the coach role at the middle of the session. The teachers will replace regular classroom activities with PALS activities so that the total amount of math instruction time will be the same. PALS Math program will be implemented twice a week. Treatment 1 phase also takes place for 2.5 weeks. On-task and off-task data will be collected 2 times a week for 2.5 weeks during PALS sessions. Math progress will be examined at the end of each week, similar to Baseline 1 phase. Baseline 2 and Treatment 2 will be similar to Baseline 1 and Treatment 1 phases relatively. Each phase will take 2.5 weeks. In total, ten weeks of a school semester will be needed for the research.

Multiple baseline design. To implement a multiple baseline design, the three participants (Student A, Student B, and Student C) have to be placed in three different classrooms. Ten consecutive school weeks are needed for this research. For Student A, Baseline phase will occur for three weeks. On-task and off-task behavior will be observed five times during math instruction throughout the baseline phase; and math performance will be measured at the end of each week. Student A's teacher will implement their typical practice during the school year for baseline phase. Starting from Week 4, the teacher's typical practice will be replaced by PALS math during math instruction twice a week for 7 weeks (Treatment phase). Behavioral engagement data will be collected 13 times throughout the time and M-COMP will be used to measure Student A's math progress at the end of each week for 7 weeks.

For Student B, the only differences from student A will be the time length of Baseline and Treatment phases and data collection frequency. The classroom will have regular math activities for the first 5 weeks with engagement being observed 9 times throughout the baseline phase and math performance being measured 5 times (once each week). Treatment phase will take place for 5 weeks after the baseline phase. The frequency of data collection during Treatment will be the same with Baseline phase.

For Student C, Baseline phase will be for 7 weeks and Treatment phase for 3 weeks. During the 7-week Baseline, the observer will collect engagement data 13 times throughout the phase; math performance will be measured at the end of each week (7 times in total). While engagement will be measured 5 times and math performance data will be collected 3 times throughout the 3-week Treatment phase.

Data analysis plan

First, baseline and treatment results will be graphed to demonstrate participants' outcomes (i.e., on-task behavior, off-task behavior, and math performance) over time. Second, Percentage Exceeding the Median Trend (PET-T; Wolery, Busick, Reichow, & Barton, 2008) and Improvement Rate Difference (IRD; Parker, Vannest, & Brown, 2009) will be used for within-case data analysis. PEM-T is defined as the percentage of observations in treatment that have better results than the split-middle trend line projected from baseline (see Formula b). This method takes both level and trend of the outcome into consideration. IRD is characterized as the difference of rates between treatment improvement and baseline improvement (see Formula c). The improvement rate is calculated as the total number of improved data points divided by the total number of data points in phase (see Formula d). IRD adjusts for trend and overlap of the results.

$$\text{(a)}\quad \text{PED-T} = \frac{\substack{number\ of\ data\ points\ in\ the\ treatment\ phase\ which\ exceed \\ the\ split\!-\!middle\ trend\ line\ from\ the\ previous\ baseline\ phase}}{total\ number\ of\ data\ points\ in\ the\ treatment\ phase} \times 100$$

(b) IRD = IR_{Tx} - IR_{Ba}

(c) IR = $\frac{number\ of\ total\ improved\ data\ points}{number\ of\ total\ data\ points\ in\ phase}$

In addition, between-case effect sizes will be calculated using Hedges' g (Hedges, Pustejovsky, & Shadish, 2012, 2013). For each case, the treatment effect is measured as the change in mean outcome between phases. There are three estimates of treatment effect in an ABAB design or a multiple baseline design with 3 participants. The average treatment effect is calculated as the effect size.

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