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Evaluating The Efficacy of an Adaptation of PALS for Math in a Seventh Grade Classroom

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**EVALUATING THE EFFICACY OF AN ADAPTATION OF PALS FOR MATH
IN A SEVENTH GRADE CLASSROOM**

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This manuscript represents a dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Psychology (in School Psychology)

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May 2012

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An Abstract of the Dissertation Submitted in Partial Fulfillment of the Requirements for
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In an attempt to validate and expand the potential application of PALS for math in a wider variety of settings, this research study examined the effects of implementing a modified version of PALS for math with seventh grade students in regular education mathematics classes. Utilizing a pre-post group design with a nested within-subject ABC single case design, the results of this study suggested that an adaptation of PALS for math for seventh grade students resulted in significant improvement in posttest mathematics computation performance within the experimental group when their pretest mathematics computation scores were considered as covariates. When comparing the performance of lower performing and higher-performing students, lower performing students demonstrated higher average weekly ROI in comparison to higher-performing students.

The results of this study suggest that implementing an adaptation of PALS for math with seventh grade students systematically provides opportunities for all students to engage in mathematical computation practice and provides students with high levels of error correction and feedback. PALS for math provides educators with a supplementary intervention that helps to support groups of students with diverse levels of mathematics achievement. The limitations and implications for future research are considered.

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Introduction

During the 20th century, the United States was a frontrunner in mathematical competence, which in turn brought numerous advantages in technology, medicine, health, defense, and economics. However, recent reports of student progress, based on the National Assessment of Educational Progress (NAEP), indicated that 32% of American eighth graders are performing proficiently in mathematics and only 23% of American twelfth graders are performing proficiently in mathematics (National Mathematics Advisory Panel, 2008). Without considerable changes to our current educational system, the United States will be forced to resign as a leader in technical expertise. In addition to the success of the nation as a whole, improvement in mathematics instruction is also of considerable importance to individual students and families. Success in mathematics, particularly in Algebra, provides students with an increased likelihood for future accomplishments and economic opportunities. More specifically, research has demonstrated that students who complete Algebra II are more than twice as likely to receive college degrees.

The National Mathematics Advisory Panel (2008) reported that there is a notable decline in mathematics proficiency as students in the United States reach late middle school and begin to engage with more advanced mathematical concepts, particularly Algebra. Thus, researchers and educators have begun to explore ways to better set the foundation for preparing students to be successful with more advanced material. The National Mathematics Advisory Panel (2008) identified difficulties with fractions and integers as two significant, yet common, barriers to students' success with Algebra. Additionally, the National Mathematics Advisory Panel (2008) identified instructional

strategies that offer opportunities for increased student learning, such as peer assisted learning.

Peer assisted learning is a type of interactive learning, which may be used to support students in a socially inclusive manner in core curriculum areas, such as mathematics and literacy. In chapter seven of the National Mathematics Advisory Panel's Final Report (2008), the topics of teacher-directed and student-centered instruction are explored. As stated in the report, cooperative learning may be used for a variety of purposes, including: tutoring, enrichment, brainstorming, and as an intermittent substitute for independent practice. While research suggests that collaborative learning may be beneficial for student learning outcomes, the panel suggested that classroom instruction in mathematics should not be entirely teacher-directed or entirely student-centered. Instead, the panel suggested that components from both of these teaching methodologies could be combined in an effort to support student learning. Multiple cooperative learning approaches exist, including: Team Assisted Individualization (TAI), Student Teams-Achievement Division, Peer-Assisted Learning Strategies (PALS) for math, and a range of other variations on peer-to-peer learning. The panel suggested that some evidence does exist to support the use of peer tutoring at the elementary grades; however, additional research on this topic is necessary.

The purpose of this study was to examine the effects of implementing a modified version of PALS with seventh grade students in regular education mathematics classes. The focus of the supplemental instruction was on two of the problematic skill areas identified by the National Mathematics Advisory Panel: fractions and integers. More specifically, the researcher investigated the extent to which an adaptation of PALS for

math, as a supplement to an existing curriculum, would result in a greater increase in math performance among seventh grade students, in comparison to having students complete math problem worksheets independently. Furthermore, the study examined the extent to which lower performing and higher-performing students benefitted from the intervention.

Description of the Intervention

PALS for math is a form of dyadic instruction that has demonstrated efficacy for improving mathematics computation, as well as concepts and application skills, among various populations of students in Kindergarten through sixth grade. A version of class-wide peer tutoring (CWPT), PALS for math is designed as a way to increase the amount of time that students spend engaged in math practice and also to increase opportunities to receive immediate corrective feedback. PALS for math was developed by Doug Fuchs, PhD, and Lynn Fuchs, PhD, in an effort to expand the types of mathematics skills targeted by CWPT (Fuchs, Fuchs, Karns, & Phillips, 2009). Extending beyond CWPT's supplemental instruction for math facts, PALS for math includes materials to supplement instruction on calculation, concepts, and applications within the general curriculum for students in Kindergarten through sixth grade. The efficacy of this program has been demonstrated through research and PALS for math is currently listed as an effective educational practice in the Johns Hopkins University's Best Evidence Encyclopedia (Johns Hopkins University, 2012).

This intervention involves assigning students into pairs, based on mathematics skills, and providing opportunities for the pairs to engage in peer-to-peer learning sessions twice per week for about 30 minutes per session. Each PALS for math unit is

designed to cover a specific mathematics topic over a period of two weeks, or four sessions. PALS for math includes many of the components that are considered essential for teaching new academic skills, including: the use of small interactive groups during instruction, the use of directed questioning and responses, breaking tasks down into parts and gradually fading prompts, and the use of extensive practice with feedback.

During each session, the students complete two major activities: coaching and practice. During coaching, each member of the pair takes a turn playing the roles of coach and player. The higher-performing student of each pair is assigned the role of first coach and coaches the first half of a coaching worksheet. During coaching, the student follows a scripted, stepwise guide to solving the particular problem type, while also providing immediate error correction. The lower performing student is assigned the role of second coach and coaches during the second half of the coaching worksheet. During the coaching portion of the session, the teacher monitors the pairs and awards points to each pair on a point sheet, contingent on appropriate behavior. During practice, students independently complete a timed drill practice worksheet, which contains a variety of types of math problems. After five minutes have elapsed, students switch practice worksheets with their partners and score one point for each correctly answered math problem. Each student in each pair marks his or her earned points during the practice session on his or her point sheet and the pair with the highest score is recognized and congratulated.

An important component of PALS for math is the implementation of student training lessons. Before the intervention is implemented with the students, a training procedure is completed with the entire class. Training procedures are outlined over the

course of five class days in the teacher's manual of the intervention materials. Scripts and outlines are available for each of the five days of training. Additionally, videos are available to provide students with a model of appropriate interactions and to assist in student comprehension. The cost of PALS for math implementation is relatively affordable and is advertised as being practical and effective (Vanderbilt Kennedy Center, 2012). A summary of the research related to PALS for math follows in this literature review.

Literature Review

Research Support for the Components of PALS for Math

PALS for math was originally designed based on CWPT, which was initially developed at Juniper Gardens Children's Project in Kansas City (Delquadri, Greenwood, Whorton, Carte, & Hall, 1986). CWPT is a dyadic form of instruction that has demonstrated efficacy for teaching math facts and computation to elementary-aged students. This instructional procedure is based on several principles, such as: providing increased opportunities for students to respond, focusing on the functionality of academic skill areas, and implementing behavioral principles to encourage responding. Similar to CWPT, PALS for math also includes dyadic instruction and peer-to-peer learning. In addition, PALS for math includes a training period, in order to ensure that students understand the purpose of PALS for math, as well as their roles and responsibilities during each lesson. This section of the literature review will explore the research that supports the essential features of PALS for math: CWPT and the inclusion of a training period for student participants.

Class-wide Peer Tutoring (CWPT). Greenwood, Delquadri, and Hall (1989) conducted a four-year longitudinal investigation, centered on the efficacy of CWPT. The researchers focused their investigation around comparing the differences between the classroom dynamics, student behaviors, and academic achievement of low-SES and high-SES elementary students. More specifically, the authors were interested to see how a CWPT intervention would impact student learning over the course of four years. The sample consisted of 94 first, second, third, and fourth grade classroom teachers and a total of 416 first grade students from two low-SES elementary schools and one high-SES elementary school. From this sample, three groups were created: a low-SES experimental group (CWPT), a low-SES control group (teacher-designed instructional program), and a high-SES comparison group. The following measures were used in an effort to compare differences in classroom dynamics, student behavior, and academic achievement: Otis Lennon School Abilities Test-Primary I, Form R; direct classroom observations, Code for Instructional Structure and Beauregard Academic Response (CISSAR); and the Metropolitan Test-Basic Battery.

The results of this longitudinal study suggest that the CWPT group spent less time in nonacademic activities and transitions than both the control group and the comparison group. In addition, the CWPT students who were considered to be at-risk for academic delays exceeded or approached the national norm in reading, language, and mathematics. The researchers found that the implementation of CWPT produced improved classroom dynamics, student behavior, and student achievement. This study demonstrated the power of peer-to-peer learning and suggests that students from low-SES backgrounds and

students who are at-risk for academic delays may benefit from CWPT and experience improved academic outcomes.

The majority of the research on CWPT demonstrates its effectiveness with basic, elementary level mathematical skills; however, very little research is available regarding how CWPT may be used to support the development of applications and higher order thinking skills. Additionally, very few studies have been published evaluating the effects of CWPT in heterogeneous middle school classrooms. Allsopp (1997) conducted a study in an effort to examine the effectiveness of CWPT in heterogeneous eighth grade math classrooms, teaching algebra problem-solving skills. The sample consisted of 262 students in eighth grade classrooms. Of these 262 students, 99 students were considered to be at-risk for math failure and 163 were considered to be not at-risk for math failure. The researchers used a pretest-posttest design in order to compare the effectiveness of the use of CWPT to independent student practice. The following measures were used to assess student achievement and social validity: California Test of Basic Skills (CTBS), a 19-item Likert scale evaluation inventory, and an informal survey.

The results of this study suggest that both CWPT and independent student practice were found to be effective strategies for helping students learn beginning algebra skills. A repeated measures ANOVA revealed that neither strategy was significantly more effective than the other; however, student and teacher responses on the social validity measures suggested that both the students and the teachers involved in this study enjoyed using CWPT. The authors suggested that lack of significant findings of this study might be attributable to the characteristics of middle school students and the middle school curriculum. For example, the authors stated that middle school students might be less

motivated by the group contingency reinforcement present in the CWPT protocol. In addition, the middle school curriculum required the students to master higher-order problem solving skills, which may have made the presentation of prompts and the scoring of answers less straightforward than the elementary implementation of CWPT. The authors suggested that future research should focus on how CWPT procedures may be modified so that they may be more appropriate and effective for middle school students.

The importance of student training. One of the essential components of PALS for math is a training period for students, which is presented to the students before they begin working in pairs. The training period provides students with information about the basic PALS for math process, in order to ensure that students understand the purpose of PALS for math, as well as the roles and responsibilities during each lesson. Fuchs, Fuchs, Bentz, Phillips, and Hamlett (1994) conducted a study to examine the effects of previous student training and experience in peer tutoring on the quality of student interactions. Sixteen third, fourth, and fifth grade general education classrooms were assigned to two conditions: an experimental group that received training and experience in peer tutoring (PT) and a control group that did not receive training in PT (no-PT). The students in the PT group received five 30-minute sessions of training. The researchers utilized measures among three different levels of analysis. Level one measures examined the following: the duration of the tutoring sessions, the accuracy of the students' performance during tutoring sessions, and systematic observations of student interactions during tutoring. Level two measures included blind, global judgments and classifications of tutoring performance. Level three analysis examined transcripts of representative cases.

The findings from the first level of analysis demonstrated a significant difference for the average session length across tasks. The PT group averaged 7.72 minutes per task, while the no-PT group averaged 5.73 minutes (effect size=1.36). The percentage of correct problems completed on far-transfer tasks was significantly higher for the PT group (89.50 percent correct) than the no-PT group (43.88 percent correct) with an effect size of 1.41. Performance on near-transfer tasks was comparable between groups (effect size=.18). The findings from the second level of analysis demonstrated that the PT group received significantly higher ratings from blind observers [3.69 (SD=1.33)] than the no-PT group [2.44 (SD=.68)]. Findings from the third level of analysis revealed that the PT tutor provided more interactions with his partner and also provided more opportunities for the tutee to respond. In contrast, the researchers noted that the no-PT tutor more often verbally completed problems in their entirety, while the tutee sat and watched. In summary, the findings of this study suggest that the group that had received training on PT was better able to provide explanations, use appropriate interactions, and comply with instructional principles than the no-PT group.

Fuchs, Fuchs, Hamlett, Phillips, Karns, and Dutka (1997) attempted to extend the previous research on promoting effective helping behavior during collaborative learning activities. The sample consisted of 40 second, third and fourth grade general education classrooms, each with at least one student identified with a learning disability. Of the sample of 40 classrooms, three conditions were created: a group of 10 classrooms used peer-mediated instruction (PMI) and received one lesson on how to offer and request elaborated help (PMI-Elaborated), a group of 10 classrooms used PMI and received the lesson on elaborated help and also received a lesson on methods for providing conceptual

mathematical explanations (PMI-Elaborated + Conceptual), and a group of 20 classrooms used the teacher-directed curriculum that was being used across all 40 classrooms and did not use PMI (no-PMI). The researchers used two measures to evaluate the differences between groups: the Comprehensive Mathematics Test and in situ observations.

The researchers reported that academic improvement in the PMI-Elaborated + Conceptual group significantly exceeded the PMI-Elaborated group ($p=.018$) and the no-PMI group ($p=.0001$). Additionally, academic improvement in the PMI-Elaborated group significantly exceeded the no-PMI group ($p=.004$). The effect size, comparing the PMI-Elaborated + Conceptual group and the no-PMI group was .73. When comparing the PMI-Elaborated and no-PMI group, the effect size was .42. Finally, the effect size comparing the two PMI groups was .32. A constructive style of interaction was more typically observed in both PMI groups. Additionally, the PMI-Elaborated + Conceptual group tutors asked more procedural questions than the PMI-Elaborated group tutors. The results of this study support the incorporation of a student-training session, before the implementation of a peer-to-peer learning intervention in a classroom.

Research Support for PALS for Math

The efficacy of PALS for math at the elementary level. Fuchs, Fuchs, Phillips, Hamlett, and Karns (1995) sought to extend the research on peer-to-peer learning in three ways. First, the researchers wanted to examine the effects of PALS for math among a variety of learners in a general education setting. Secondly, the researchers wanted to expand the use of peer-to-peer learning from mathematics computation to mathematics concepts and applications. The third focus of the study was to investigate the effects of PALS for math on nonacademic, classroom dynamics. The sample consisted of 40 second,

third, and fourth grade general education classrooms, each with at least one student identified with a learning disability. The sample was split into two conditions: teacher-mediated instruction with PALS and teacher-mediated instruction without PALS. It is important to note here that PALS for math replaced components of, rather than added to, the existing teacher-mediated instruction. Within these two groups, students were identified as learning-disabled, low-achieving, and average-achieving students. The researchers utilized a pretest-posttest design and employed the following measures: instructional planning sheets, the Teacher Planning Scale, the Math Operations Test-Revised (MOT-R), and the Mathematics Concepts and Applications Test (MCAT).

The authors of this study reported that a significant difference was found among learning-disabled, low-achieving, and average-achieving students between groups on both the MOT-R and the MCAT. On the MOT-R, the effect sizes are reported as .30 for students with learning disabilities and .95 for students who had been identified as low-achieving. Results of the Teacher Planning Scale suggested that PALS wasted less instructional time and helped to keep the classrooms running smoothly. The results of this study suggest that PALS for math may be a beneficial intervention for students with a variety of learning histories. Additionally, the results of this study suggest that PALS for math may improve a classroom's efficiency and organization.

In an effort to expand the age-range with which PALS for math had been shown to be effective, Fuchs, Fuchs, and Karns (2001) designed a study to examine the effects of PALS for math on Kindergarten students' mathematics achievement. The sample consisted of 168 Kindergarten students from 20 different Kindergarten classrooms. All 20 of the Kindergarten teachers followed the district's core curriculum, *Math Advantage*.

The treatment group (PALS) consisted of 10 teachers who used PALS for math to replace other math activities, so that the overall time allocated to mathematics each week remained constant for both groups. The control group teachers (no-PALS) continued to use the *Math Advantage* curriculum with their students. Based on the results of the Stanford Early School Achievement Test (SESAT), the students were classified as high-achieving students, medium-achieving students, and low-achieving students. Additionally, students with disabilities were noted. In addition to the SESAT, the researchers also used the mathematics section of the Primary 1 level of the Stanford Achievement Test and a teacher questionnaire to collect data on student improvement and social validity.

The authors of this study reported that the growth of the PALS group on the SESAT ($M=6.80$, $SD=4.69$) exceeded that of the no-PALS group ($M=4.86$, $SD=4.05$) with an effect size of .24. However, no significant differences were found between the PALS group and the no-PALS group on the Stanford Achievement Test. The authors stated that of the two measures used to assess mathematics achievement, the SESAT was more closely aligned with the PALS for math program content. PALS demonstrated larger effect sizes among initially classified medium-achieving students (.53), low-achieving students (.46), and students with disabilities (.41) than for students who were initially classified as high-achieving students (-.20). The results of this study suggest that PALS for math may promote student learning and achievement at the Kindergarten level.

In an effort to expand the research further, Fuchs, Fuchs, Yazdian, and Powel (2002) sought to examine the effects of PALS on the development of mathematics skills among first grade students. The sample consisted of 327 first grade students within 20 different first grade classrooms. All 20 of the participating teachers continued to follow

the district's core curriculum, *Math Advantage*. The 10 participating teachers in the experimental condition (PALS) replaced parts of the core curriculum with PALS for math, while the 10 participating teachers in the control condition (no-PALS) continued to implement the *Math Advantage* curriculum without any supplemental interventions in place. At the start of the study, each teacher was asked to classify each of his or her students based on mathematics proficiency as high-achieving, average-achieving, and low-achieving students. The researchers utilized a pretest-posttest design and used a measure of academic achievement and a measure of social validity for data collection. In order to measure academic achievement, the researchers selected 94 items from the Primary 1 level and the Primary 2 level of the Stanford Achievement Test and coded the selection into those questions that were aligned with PALS for math content and those that were not aligned with PALS for math content. In addition, a teacher questionnaire was developed as a measure of social validity.

On the aligned portion of the Stanford Achievement Test, the average improvement of students in the PALS group exceeded the average improvement of the students in the no-PALS group [$F_{(1, 325)} = 5.66, p < .018$] with an effect size of .31. Effect sizes for students who had been identified as high-achieving students, average-achieving students, and low-achieving students were .31, .33, and .34, respectively. No significant differences were reported between the two groups on the unaligned portion of the Stanford Achievement Test. In the case of students with disabilities in the PALS group, the average improvement on the aligned portion of the Stanford Achievement Test was 16.00, while the average improvement for students with disabilities in the no-PALS group was 10.10, resulting in an effect size of .68. In addition to improved mathematics

skills, teacher perception data from the social validity measure indicated that the participating teachers generally considered PALS for math to be a practical intervention for classroom use.

The efficacy of PALS for math at the secondary level. Much of the research supporting the efficacy of PALS for math has examined the effects of the intervention when used with a sample of elementary students. In an effort to extend the research to additional populations, Calhoun and Fuchs (2003) designed a study to examine how PALS for math and curriculum-based measurement (CBM) impacted the mathematics performance of secondary students with disabilities. The sample consisted of 92 students in ninth through twelfth grade, all of whom received mathematics instruction in self-contained resource rooms. This sample was taken from 10 resources classrooms from three different high schools. Five of the 10 classrooms were assigned to the treatment condition (PALS + CBM). The treatment condition utilized PALS, a tangible reinforcement structure, and CBM. The students in the control condition were provided instruction using the *Buckle Down on Tennessee Mathematics* workbook. The researchers utilized a pretest-posttest design and used the following measures: the Math Operations Test-Revised (MOT-R), the Math Concepts and Applications Test (MCAT), the mathematics section of the Tennessee Comprehension Achievement Test (TCAP), a student questionnaire, and a teacher questionnaire.

The results of this study demonstrated a moderate effect size of .40 for students in the PALS + CBM group for improvement on computation skills. Both groups improved significantly in math concepts and applications; however, no significant difference was found between the two groups. Social validity measures indicated that both the teachers

and the students enjoyed using PALS for math and felt that the intervention was helpful in increasing mathematics skills. In addition, both the teachers and the students felt that using CBM to graph progress helped to increase motivation. Finally, the majority of teachers and students agreed that they would like to participate in PALS for math and CBM again. This study demonstrates that PALS for math may be an effective intervention for providing instruction to students with disabilities at the high school level.

The social validity of PALS for math. Previously published studies had provided information and data about the effectiveness of PALS for math on students' achievement in mathematics, as well as some information regarding the social validity of this supplemental intervention. In an effort to investigate the likelihood and success of sustained use of PALS for math at the elementary level, Baker, Gersten, Dimino, and Griffiths (2004) designed a study to examine whether teachers who had previously been involved in research studies related to PALS for math maintained their use of PALS for math after the research studies ended. The participants in this study consisted of nine second, third, and fourth grade teachers, eight of whom had been involved in the study conducted by Fuchs, Fuchs, Bentz et al. in 1994. The authors utilized a case study design and collected data using the following measures: semi-structured interviews, two sets of classroom observations (observations of PALS implementation and observations of general math instruction), the Stages of Concern survey, the Teacher Efficacy Measure, and the Teacher Community, Professionalism, and Job Satisfaction Scales.

The authors reported that all eight of the teachers who had originally been involved in the 1994 study had continued to utilize PALS for math in their classrooms on a regular basis. In regard to procedural fidelity, teachers completed, on average, 96% of

the teacher-related intervention components correctly. In addition, 99% of the student-related intervention components were completed correctly. In contrast, the new teacher who had not been present during the original study reportedly had great difficulty implementing the intervention effectively. When asked about her familiarity with the intervention, she reported having a negative experience when receiving professional development on how to implement PALS for math, stating that the PALS coordinator took over the teaching of the lesson and never truly trained her. This study demonstrates that the successful sustained use of the PALS for math intervention is possible when effective training is provided to teachers; however, it also serves as a reminder that professional development must be modified to meet the needs of individual teachers in order for teachers to feel autonomous enough to implement the intervention with fidelity.

Kroeger and Kouche (2006) wrote about their own experiences with PALS for math in an effort to describe how the addition of PALS for math may influence the teachers and the students in middle school mathematics classes. The sample consisted of 150 seventh grade students. Of these students, 14 percent had been identified with a disability, six had behavior plans, and two had received diagnoses of Asperger's syndrome. The authors of this article were a math teacher and an intervention specialist. These two educators worked together to implement the supplemental intervention within the teacher's seventh grade classrooms. The authors used a case study design and conducted informal interviews in order to collect information about the experiences and perceptions of the students. Additionally, the teacher and the intervention specialist summarized their own perceptions and experiences with PALS for math.

The data collected from the interviews suggest that the participants found PALS for math to be beneficial in the classroom. The classroom teacher reported that 100% of the students were engaged while they were working in pairs on PALS. Additionally, she reported that she observed the confidence levels of many students rise. Students' scores on quizzes and students' retention material were reported to have improved as well. The intervention specialist reported that the students with IEPs benefitted from the social skills built into the program. The majority of the students reported that they enjoyed using PALS and that this supplemental intervention helped them better understand mathematics.

Summary of Literature Review

The existing literature on PALS for math suggests that the components of this intervention, based on CWPT, are grounded in evidence-based literature (Delquardi et al., 1986; Greenwood et al., 1989; Allsopp, 1997). Additionally, the inclusion of training procedures for students and teachers appears to be an essential element for student success with this intervention (Fuchs et al., 1994; Fuchs et al., 1997). The research also suggests that PALS for math has demonstrated efficacy among students in elementary school in general education classrooms. These published studies have demonstrated that students with a wide variety of learning histories may benefit from this type of supplemental mathematics intervention. More specifically, students who have been classified as high-achieving, average-achieving, and low achieving, as well as students with disabilities may benefit from PALS for math (Fuchs et al., 1995; Fuchs et al., 2001; Fuchs et al., 2002). Additionally, studies have demonstrated the social validity of this intervention and report that teachers and students generally enjoy using this intervention

(Fuchs et al., 1995; Fuchs et al., 2001; Fuchs et al., 2002; Calhoon & Fuchs, 2003; Kroeger and Kouche, 2006). Additionally, teachers will sustain the use of this intervention when proper training has been provided (Baker et al., 2004). In regard to secondary classrooms, only one study demonstrating the efficacy of PALS could be found (Calhoon & Fuchs, 2003).

As increased advocacy for collaborative learning has appeared within the field of education over the past several decades, the necessity for research on this topic has also increased. While research on the topic of PALS for math has begun to demonstrate the efficacy of this intervention, areas for future research do exist. Particularly, research with students at the middle school and high school level is essential. Specifically, researchers could investigate whether this intervention is effective with middle and high school populations and curricula. Additionally, researchers may want to investigate whether modifications to the training procedures, session implementation, and materials need to be modified in order for PALS for math to be effective with this older age group. PALS for math appears to offer some promising results for students in regard to mathematics achievement; however, a stronger research base is necessary in order to validate and expand the potential uses of this intervention in a wider variety of settings.

Research Questions and Hypotheses

Research has demonstrated that success in Algebra is a gateway to later achievement; however, many students begin to demonstrate increased difficulty with mathematics as they enter late middle school (National Mathematics Advisory Panel, 2008). Given the common difficulties that students have with mathematics as they enter late middle school, it is important to explore the ways in which student achievement in

mathematics during this critical time period may be increased. As a supplement to a general curriculum, PALS for math offers a methodology for educators to use in an effort to support students at the Tier One (i.e., core curriculum) level. While currently published research has demonstrated the efficacy of this intervention among kindergarten through sixth grade students, additional research is needed to determine whether PALS is effective for secondary level students and specialized populations. In an attempt to validate and expand the potential application of PALS for math in a wider variety of settings, this research study examined the effects of implementing a modified version of PALS with seventh grade students in regular education mathematics classes. The research questions for this study are as follows:

1. Will the implementation of PALS for math, as a supplement to an existing curriculum, result in a greater increase in math performance among seventh grade students, in comparison to when PALS for math does not supplement an existing curriculum?
2. Will PALS for math benefit some students more than others?
3. Will three lower performing students demonstrate improved performance in fractions computation during the phase in which the intervention includes collaborative practice with fractions? Furthermore, will three lower performing students demonstrate improved performance in integer computation during the phase in which the intervention includes collaborative practice with integers?

Based on a review of the PALS for math curricular materials and the current research that has been published about the efficacy of PALS for math, the following research hypotheses were made:

1. The implementation of PALS for math, as a supplement to an existing curriculum, will result in a greater increase in math performance among seventh grade students, in comparison to when PALS for math does not supplement an existing curriculum.
2. PALS for math will benefit all students, but will be more beneficial to those students scoring below the 50th percentile on the Math Computation (M-COMP) CBM from AIMSweb.
3. During the phase in which the intervention includes collaborative practice with fractions, the three lower performing students will demonstrate an improvement in fractions computation. Similarly, during the phase in which the intervention includes collaborative practice with integers, the three lower performing students will demonstrate an improvement in integers computation.

Method

Design

This study utilized a pre-post group design with a nested within-subject ABC case study design. In regard to the pre-post group design, intact seventh grade math classes were used and comparisons were made between the students' class-wide mean scores on generalized outcomes measures of math skills. Prior to receiving the PALS for math intervention, both groups completed pretest measures: AIMSweb Math Computation (M-

COMP) and researcher-created Fractions-CBM. Following the intervention, both groups completed posttest measures with M-COMP and Fractions-CBM and the class means were compared.

In regard to the nested within-subjects comparison, an ABC case study design was used to explore the impact of the intervention for three lower performing students as they learned two different mathematics skills: fractions computation skills and computation skills with positive and negative integers. These three students were selected based on two criteria: (1) they were not receiving any special education or RTI services for mathematics and (2) they were the lowest scoring participants on the M-COMP during the baseline phase. These three students completed weekly Fractions-CBM and weekly Integers-CBM throughout all phases of the study. During the next phase (B), these students participated in the class wide implementation of PALS for math, during which the focus of the intervention was on fractions computation skills. After four weeks, when this phase of the study ceased, data were collected on the students' general math computation performance. Following, the next phase (C) began, during which the focus of the class wide intervention changed to integers. After four weeks, when this phase of the study ceased, data were again collected on the students' general math computation performance.

Participants

The participants of this study were middle school students and the mathematics teacher in two regular education seventh grade mathematics classes in a suburban school located in the Northeast. The school served grades six through eight and had a total enrollment of 624. At the time of the study, 22.37% of the total school population

qualified for free/reduced-price lunch, 0.16% of the total school population was identified as being English language learners (ELL), and 12.98% of the total school population received special education services. The host district student data policy prohibited release of classroom-specific demographic data. The student participants included all of the students on one seventh grade “team.” The experimental group contained 21 total seventh grade students (12 male and 9 female). The control group contained 20 total seventh grade students (10 male and 10 female). The majority of the students had attended school in the same town since Kindergarten. A summary of student and school information is found in Table 1. The three lower performing students were all general education students who did not receive any supplementary math supports (i.e., Response to Intervention). Two of the lower performing students were males and one was female. The teacher who participated in the study worked on the team with one other teacher and together they provided the language arts, math, science, and social studies instruction for 41 students. The teacher participant was the math and social studies teacher. This teacher had 25 years of teaching experience at the middle school level, primarily teaching math.

Table 1.

Participant and School Demographics

	Percent
Participants	
Boys	54
Girls	46
School	
English Language Learners	.16
Free and Reduced Lunch	22.37
Special Education	12.98

Setting

The setting for this study was a regular education seventh grade mathematics classroom. The classroom contained approximately 19 to 21 students at a time, the mathematics teacher, and one or two graduate students who collected data on student progress and treatment fidelity. Each mathematics class received instruction in the same classroom by the same mathematics teacher. All training, intervention, and no-intervention sessions took place in the same classroom.

Materials

Assessment materials. A selection of assessment tools was utilized in order to measure student performance and progress. A total of three different assessments tools were used: M-COMP, researcher-created Fractions-CBM, and researcher-created Integers-CBM.

M-COMP. In order to collect data on students' mathematics comprehension M-COMP CBM probes from AIMSweb® were used (Pearson, 2010). The 8-minute assessment was administered in a group setting and was given in accordance to the standardized procedures described by AIMSweb®. M-COMP was used to collect baseline data of student performance and as a pre- and posttest measure of student performance.

Researcher-created Fractions-CBM and Integers-CBM. In addition, the researcher created more specific CBM probes to reflect the local curriculum (McDougall-Littell *Integrated Mathematics 2*) and to target the specific skills being taught during each mathematics unit of study: Fractions-CBM and Integers-CBM (Larson, Boswell, Kanold, & Stiff, 2004). These brief assessments were created with the test generator software that

was provided with the curriculum materials. These researcher-created CBM probes were administered in a group setting and took four minutes for students to complete. The Fractions-CBM were administered as a progress monitoring tool on a weekly basis to all students during the Fractions Phase of the study and to three lower performing students in the PALS Group during Phase-B of the study. The Integers-CBM were administered as a progress-monitoring tool on a weekly basis to three lower performing students in the PALS Group during the Fractions Phase and the Integers Phase of the study.

Training materials. The PALS for math Teacher Manual and DVD were used to guide teacher and student training (Fuchs et al., 2009). Teacher training was provided by the researcher prior to implementing the PALS for math intervention. Teacher training sessions included treatment modeling, direct instruction, and independent practice. During student training, the teacher utilized the student training scripts within the Teacher Manual to guide student training (Fuchs et al, 2009). The student training scripts may be found on pages 35 through 60 in the PALS for Math Teacher Manual (Fuchs et al., 2009).

Intervention materials. The currently published version of PALS includes materials up through sixth grade. In order to explore whether PALS was effective for seventh grade students, the PALS method was applied to math activities matched to the participants' math curriculum, McDougall-Littell *Integrated Mathematics 2* (Larson et al., 2004). The specific instructional activities for the duration of the study were sampled to create PALS items and CBM probes matched to the textbook material. The PALS for math Teacher Manual was used to guide intervention implementation (Fuchs et al, 2009). Materials specific to PALS for math are listed in the Teacher Manual and include: folders,

Coach's Question Sheets, Coaching Sheets, Coaching Answer Sheets, Practice Sheets, Practice Answer Sheets, Point Sheets, and several posters that may be displayed on the classroom walls (Fuchs et al, 2009). Materials in need of modification were created using the test generator software that is provided with the McDougall-Littell *Integrated Mathematics 2* curriculum materials. These materials were made to match the format of the published PALS materials. Due to the adaptation of PALS for seventh grade students, the researcher consulted weekly with the teacher in order to gather information about the appropriateness of the PALS content for the students' instructional level. Based on this information, the researcher selected and modified PALS materials in order to include relevant practice materials.

Procedures and Schedule

Baseline. The study began with a baseline phase during which the students in both math classes completed three M-COMP assessments and three Fractions-CBM. The median score of each of these measures served as the pretest measure. The three lower performing students from the PALS Group were selected, based on M-COMP performance, to participate in the ABC case study component. These students completed additional CBM (Integers-CBM) during phase C of the study. After the pretest data were obtained, the math teacher implemented the PALS in one of the classrooms (PALS Group).

Teacher training. Prior to starting the PALS procedure, the researcher trained the teacher to use PALS according to the PALS manual (Fuchs et al., 2009). Teacher training sessions included treatment modeling, direct instruction, and independent practice.

Training sessions were scheduled at the teacher's convenience and continued until the teacher demonstrated 100% mastery of the procedures.

Student pairing. Students were paired with partners for the PALS for math intervention based on the M-COMP results. The students were rank ordered according to their performance on the M-COMP measure. More specifically, the students were rank ordered from highest-performing to lowest-performing and numbered from one to 20 respectively. This list was used to create student pairs which had a balanced set of one higher performing and one lower performing student.

Student training. The first week of PALS implementation included training the students in the PALS Group to use PALS correctly. The PALS for math manual provides an initial student training outline and corresponding scripts that are organized over the course of five days. However, due to the fact that the participants in this study were seventh grade students and that they had received previous instruction about working collaboratively with peers, the students were able to move more quickly through the student training materials and the teacher needed only three days to present the training materials to the students. Sample student training scripts can be found in the PALS for math Teacher Manual (Fuchs et al., 2009).

Intervention: Fractions Phase. The focus of the PALS intervention during the Fractions Phase was on fractions computation. The Fractions Phase began after student training had been completed. Within the PALS Group, the PALS intervention was implemented two times per week for 30 minutes each. During PALS implementation, the teacher followed the procedures outlined on the PALS Command Card, which may be found within the PALS for Math Teacher Manual (Fuchs, et al., 2009). A description of

the materials used during a typical PALS lesson, may be found on pages 11 through 14 of the PALS for Math Teacher Manual (Fuchs et al., 2009). During each session, the students completed two major activities: coaching and practice. During coaching, each member of the pair took a turn playing the role of coach and player. The higher-performing student of each pair was assigned the role of first coach and coached the first half of a coaching worksheet. During coaching, the student followed a scripted, stepwise guide to solving the particular problem type, while also providing immediate error correction. The lower performing student was assigned the role of second coach and coached during the second half of the coaching worksheet. During the coaching portion of the session, the teacher monitored the pairs and awarded points to each pair on a point sheet, contingent on appropriate behavior. During practice, students independently completed a timed drill practice worksheet, which contained a variety of types of math problems. After five minutes had elapsed, students switched practice worksheets with their partners and scored one point for each correctly answered math problem. Each student in each pair marked his or her earned points during the practice session on his or her point sheet and the pair with the highest score was recognized and congratulated.

No-PALS control group. During the time block when the PALS Group completed the PALS intervention, the students in the no-pals condition (No-PALS Group) completed a worksheet with math problems similar to those on the PALS worksheets but without the PALS procedure. This ensured that the No-PALS Group participated in the same amount of math instruction as the PALS Group. In order to compare the performance of students in the PALS and no-PALS conditions, all students were given the same homework each night and completed the same weekly Fractions-

CBM probe. In addition to the weekly Fractions-CBM probes, three lower performing students in the PALS Group also completed weekly progress monitoring probes with sample items not yet taught (e.g., integers). Having selected lower performing students to complete probes which sample both targeted skills (e.g., Fractions-CBM) and untargeted skills (e.g., Integers-CBM) provided a way to determine if the PALS intervention led to within-student skill improvements specific to the target skill area: fractions.

At the end of the four-week intervention period, the M-COMP was administered to the students three times. The mean result of the M-COMP served as the posttest score for the end of The Fractions Phase.

Intervention: Integers Phase. The focus of the PALS intervention during the Integers Phase was on the computation of positive and negative integers. The same implementation standards remained in place for the duration of the Integers Phase. During the Integers Phase, only the three identified lower performing students completed CBM probes (e.g., Integers-CBM). These probes were designed to show whether these students demonstrated skill improvements in the area of integers after PALS sessions with integer content had been targeted. At the end of the four-week intervention period, the M-COMP was administered to the students three times. The mean result of the M-COMP served as the posttest score for the end of the Integers Phase.

Treatment Integrity and Assessment Accuracy

In an effort to increase the likelihood that the PALS procedures were implemented correctly, the teacher and the students were observed during 30% of the PALS and no-PALS lessons. During each observation, the observer used a checklist of the required PALS components, or of the no-PALS planned worksheet activity and

recorded whether the teacher and the students completed the intervention or worksheet activity correctly. An implementation teacher and student fidelity checklist for PALS is found in Appendix A. A second observer collected inter-observer agreement data during 50% of the observations. Additionally, in an effort to monitor any spillover effects of the PALS for math intervention into the No-PALS Group, an observer monitored 30% of the no-PALS lessons. This observation was similar to the observation that took place during the PALS sessions and involved the use of an implementation checklist for the no-PALS lessons. An implementation checklist for the no-PALS lessons may be found in Appendix B. Similarly, assessment accuracy was verified by having a second trained evaluator score 30% of the M-COMP assessments, 30% of the Fractions-CBM assessments, and 30% of the Integers-CBM assessments. Together, these data provided information concerning inter observer agreement and data accuracy.

Data Analysis Methods

To answer the first research question, information about student performance between the two groups on the M-COMP measure and the Fractions-CBM was compared using a series of t-tests. First, independent samples t-tests were run to compare the baseline M-COMP means of the two groups and the Fractions-CBM means of the two groups. These tests were run in order to determine if the baseline M-COMP performance of the two groups or the Fractions-CBM performance of the two groups differed significantly. Next, a series of paired samples t-tests were run to compare the following: (1) within-group M-COMP performance at baseline to within-group M-COMP performance at the end of The Fractions Phase, (2) within-group Fractions-CBM performance at the end of baseline to within-group Fractions-CBM performance at the

end of the Fractions Phase, (3) within-group M-COMP performance at the end of the fractions phase to within-group M-COMP performance at the end of the Integers Phase, (4) within-group M-COMP performance at baseline to within-group M-COMP performance at the end of the Integers Phase. Additional independent samples t-tests were run to compare the end of the Integers Phase M-COMP means of the two groups, as well as the end of the Fractions Phase Fractions-CBM means of the two groups. Finally, a full-factorial Analysis of Covariance (ANCOVA) was run to learn whether the differences in students' posttest M-COMP scores were significant when their pretest M-COMP scores were entered as covariates.

In an effort to answer the second research question, the participants in the PALS Group and the No-PALS Group were divided into two groups based on baseline M-COMP performance. Next, the rate of improvement (ROI) of each of these groups was calculated and compared to the AIMSweb® seventh grade M-COMP ROI, which is based on a national normative sample. To address the third research question, the results of the researcher-created local CBM probes of fractions and integer skills were graphed for the three lower performing students. Visual inspection of the trend and level of these data provided additional information about the efficacy of the PALS instruction for these students.

Results

Treatment Integrity and Assessment Accuracy

Table 2 presents the treatment integrity data for both the PALS Group and the No-PALS Group session observations. With the PALS Group, treatment integrity ranged

from 82.1% to 96.3% compliance, with an average of 93.3% compliance. With the No-PALS Group, treatment integrity consistently remained at 100%.

Table 2.

Treatment Integrity Data

	Observed Sessions								Average
	1	2	3	4	5	6	7	8	
PALS Group	90.5%	82.1%	96.2%	96.3%	96.2%	96.4%	92.6%	96.3%	93.3%
No-PALS Group	100%	100%	100%	100%	100%	100%	100%	100%	100%

Table 3 displays the percent of inter-observer agreement between two observers. 50% of the observed sessions included a second observer. With the PALS group, inter-observer agreement of treatment integrity ranged from 92.0% to 100%, with an average of 95.2%. With the No-PALS Group, inter-observer agreement of treatment integrity remained consistently at 100%.

Table 3.

Inter-Observer Agreement of Treatment Integrity

	Co-Observed Sessions				Average
	1	2	3	4	
PALS Group	92.3%	100%	92.0%	96.3%	95.2%
No-PALS Group	100%	100%	100%	100%	100%

Table 4 presents the percent of inter-observer agreement between two scorers on the three different measures used in the study: M-COMP, Fractions-CBM, and Integers-CBM. Inter-scorer agreement on the M-COMP ranged from 93.0% to 100%, with an average of 98.6%. Inter-scorer agreement on the Fractions-CBM ranged from 83.3% to 100%, with an average of 98.3%. Inter-scorer agreement on the Integers-CBM ranged from 85.7% to 100%, with an average of 97.7%.

Table 4.

Inter-Scorer Agreement of Assessment Measures

	Range	Average
M-COMP	93.0% - 100%	98.6%
Fractions-CBM	83.3% - 100%	98.3%
Integers-CBM	85.7% - 100%	97.7%

Research Question #1: PALS Effects

An independent-samples t test was calculated comparing the mean baseline M-COMP score of participants in the PALS Group to the mean baseline M-COMP score of participants in the No-PALS Group. No significant difference was found ($t_{(39)} = .850, p > .05$). The mean baseline M-COMP score of the participants in the PALS Group ($m = 38.48, sd = 16.80$) was not significantly different from the mean baseline M-COMP score of the participants in the No-PALS Group ($m = 42.45, sd = 12.73$). These results informed the subsequent data analyses. Information about the mean M-COMP scores of both groups is displayed in Table 5.

Table 5.

M-COMP Scores

	Class Average of Median M-COMP Scores		
	Baseline	End of the Fractions Phase	End of the Integers Phase
PALS Group (n=21)	38.48 (SD=16.80)	43.19 (SD=15.24)	47.95 (SD=16.32)
No-PALS Group (n=20)	42.45 (SD=12.73)	42.40 (SD=16.22)	46.10 (SD=13.49)
All Participants (n=41)	40.41 (SD=14.91)	42.80 (SD=15.53)	47.05 (SD=14.85)

A series of paired samples t -tests were run to compare the mean M-COMP scores of the students in the PALS Group at baseline, the end of the Fractions Phase, and at the end of the Integers Phase. For students in the PALS Group, the mean baseline M-COMP score of 38.48 ($sd = 16.80$) was compared to the mean end of the Fractions Phase M-

COMP score of 43.19 ($sd = 15.24$). A statistically significant increase from baseline to the end of the Fractions Phase was found ($t_{(20)} = -5.021, p < .001$). For students in the PALS Group, the mean end of the Fractions Phase score of 43.19 ($sd = 15.24$) was compared to the mean end of the Integers Phase M-COMP score of 47.95 ($sd = 16.32$). A significant increase from the end of the Fractions Phase to the end of the Integers Phase was found ($t_{(20)} = -4.374, p < .001$). For students in the PALS Group, the mean baseline M-COMP score of 38.48 ($sd = 16.80$) was compared to the mean end of the Integers Phase M-COMP score of 47.95 ($sd = 16.32$). A significant increase from baseline to the end of the Integers Phase was found ($t_{(20)} = -5.973, p < .001$).

A series of paired samples t -tests was run to compare the mean M-COMP scores of the students in the No-PALS Group at baseline, the end of the Fractions Phase, and at the end of the Integers Phase as well. For students in the No-PALS Group, the mean baseline M-COMP score of 42.45 ($sd = 12.73$) was compared to the mean end of the Fractions Phase M-COMP score of 42.40 ($sd = 16.22$). No significant difference was found from baseline to the end of the Fractions Phase ($t_{(19)} = .019, p > .05$). For students in the No-PALS Group, the mean end of the Fractions Phase score of 42.40 ($sd = 16.22$) was compared to the mean end of the Integers Phase M-COMP score of 46.10 ($sd = 13.49$). No significant difference was found from baseline to the end of the Fractions Phase ($t_{(19)} = -1.214, p > .05$). For students in the No-PALS Group, the mean baseline M-COMP score of 42.45 ($sd = 12.73$) was compared to the mean end of the Integers Phase M-COMP score of 46.10 ($sd = 13.49$). No significant difference was found from baseline to the end of the Integers Phase? ($t_{(19)} = -1.771, p > .05$).

An independent-samples t -test was calculated comparing the end of the Integers Phase M-COMP score of participants in the PALS Group to the mean end of the Integers Phase M-COMP score of participants in the No-PALS Group. No significant difference was found ($t_{(39)} = -.395, p > .05$). The mean end of the Integers Phase M-COMP score of the participants in the PALS Group ($m = 47.95, sd = 16.32$) was not significantly different from the mean end of the Integers Phase M-COMP score of the participants in the No-PALS Group ($m = 46.10, sd = 13.49$).

Another independent-samples t -test was calculated comparing the mean baseline Fractions-CBM score of participants in the PALS Group to the mean baseline Fractions-CBM score of participants in the No-PALS Group. No significant difference was found ($t_{(39)} = -1.154, p > .05$). The mean baseline Fractions-CBM score of the participants in the PALS Group ($m = 4.43, sd = 2.58$) was not significantly different from the mean baseline Fractions-CBM score of the participants in the No-PALS Group ($m = 3.60, sd = 1.96$). Information about the mean Fractions-CBM scores of both groups is displayed in Table 6.

Table 6.

Fractions-CBM Scores

	Class Average of Fraction-CBM Scores	
	Median Baseline Score	End of the Fractions Phase
PALS Group (n=21)	4.43 (SD=2.58)	8.86 (SD=4.11)
No-PALS Group (n=20)	3.60 (SD=1.96)	6.95 (SD=3.57)
All Participants (n=41)	4.02 (SD=2.31)	7.95 (SD=3.94)

For students in the PALS Group, the mean baseline Fractions-CBM score of 4.43 ($sd = 2.58$) was compared to the mean end of the Fractions Phase Fractions-CBM score of 8.86 ($sd = 4.11$). A significant increase from baseline to the end of the Fractions Phase was found ($t_{(20)} = -7.106, p < .001$). For students in the No-PALS Group, the mean

baseline Fractions-CBM score of 3.60 ($sd = 1.96$) was compared to the mean end of the Fractions Phase Fractions-CBM score of 6.95 ($sd = 3.57$). A significant increase from baseline to the end of the Fractions Phase was found ($t_{(18)} = -4.012, p < .001$). Although the students showed significant increases in their fractions scores over time, no significant difference was found ($t_{(38)} = -1.561, p > .05$) between the PALS and No-PALS groups. The mean end of the Fractions Phase Fractions-CBM score of the participants in the PALS Group ($m = 8.86, sd = 4.11$) was not significantly different from the mean end of the Fractions Phase Fractions-CBM score of the participants in the No-PALS Group ($m = 6.95, sd = 3.57$).

The differences between groups on all of the t -test comparisons were quite small. Therefore, the four-point difference between the PALS and No-PALS groups on the pretest did appear to have potentially relative significance. For this reason, an ANCOVA was run and the results may be found in Table 7. The ANCOVA results, which took into Table 7.

ANCOVA Results

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Pretest M-COMP Score	6310.310	1	6310.310	98.829	.000
Group	275.272	1	275.272	4.224	.047
Error	2476.442	38	65.170		

account the students' pretest M-COMP scores, revealed that there were statistically significant differences between the PALS and No-PALS groups at posttest ($F_{(1, 38)} = 4.224, p = .047$). This finding was different than the t -test conclusion, in that the independent t -test comparison showed no significant differences. Controlling for the pretest scores was critical in isolating the source of variance contributing to the

ANCOVA result. This finding indicates that participation in the PALS condition did impact students' posttest M-COMP scores.

Research Question #2: Outcomes by Student Groups

To answer the second research question, the participants in the PALS and No-PALS Groups were divided into two groups based on baseline M-COMP performance. Originally, the researcher had planned to create these two groups based on AIMSweb® national norms. AIMSweb® provides national norms, which are divided into percentiles; however, the AIMSweb® national normative data and the performance of the sample population were notably different. A comparison of the two groups is presented in Table 8.

Table 8.

Comparing AIMSweb® National Norms to Sample Population's Data

	AIMSweb® National Norms: Seventh Grade M-COMP Winter Benchmark Performance (n=805)	Study Participants: Seventh Grade M-COMP Baseline Performance (n=41)
90 th Percentile	50	61.60
75 th Percentile	38	49.50
50 th Percentile	27	42.00
25 th Percentile	17	28.50
10 th Percentile	10	18.40
Mean	28	40.41
Standard Deviation	15	14.91

The AIMSweb® 50th percentile score for the seventh grade winter M-COMP is 27. When dividing the study's participants into two groups (participants whose baseline M-COMP score was at or above 27 and participants whose baseline M-COMP score was below 27), only seven students were identified as scoring below 27. More specifically, there were five students in the PALS Group who scored below the AIMSweb® 50th

percentile and two students in the No-PALS Group who scored below the AIMSweb® 50th percentile. Based on these figures, the researcher divided the groups of participants based on the 50th percentile determined by the local normative score of 42. Next, each group was divided into two: participants whose baseline M-COMP score was at or above 42 (i.e., higher performing) and participants whose baseline M-COMP score was below 42 (i.e., lower performing).

Next, the ROI of each of these groups was calculated and compared to the AIMSweb® seventh grade M-COMP ROI. Table 9 presents the M-COMP average weekly ROI by group and student performance level. The results indicate that each of the

Table 9.

M-COMP Average Weekly ROI by Group and Student Performance Level

	Average Weekly ROI from Baseline to End of the Integers Phase	7 th Grade AIMSweb Average Weekly ROI
All Participants (n=41)	.74	
PALS Group (n=21)	1.05	
PALS Group: At or Above Local 50 th Percentile [Baseline M-COMP Score \geq 42 (n=11)]	.78	
PALS Group: Below Local 50 th Percentile [Baseline M-COMP Score \leq 42 (n=10)]	1.34	.28
No-PALS Group (n=20)	.41	
No-PALS Group: At or Above Local 50 th Percentile [Baseline M-COMP Score \geq 42 (n=11)]	.09	
No-PALS Group: Below Local 50 th Percentile [Baseline M-COMP Score \leq 42 (n=9)]	.79	

groups demonstrated a higher weekly ROI than the national average of .28 points per week. The highest weekly ROI was achieved by the lower performing students in the PALS Group who had scored below the locally derived 50th percentile (weekly

ROI=1.34). This group demonstrated a weekly ROI that was .56 points greater than their higher performing classmates.

Research Question #3: Lower Performing Students

Within the PALS Group, three lower performing students were identified for a nested within-subjects (i.e., ABC design) case study analysis. These three students completed additional researcher-created CBM assessments on a weekly basis: Fractions-CBM and Integers-CBM throughout both phases of the study. Table 10 displays the three lower performing students' performance on the M-COMP. Note that all names are pseudonyms.

Table 10.

M-COMP Data and Weekly ROI for Three Lower Performing Students

	Baseline Median M- COMP Score	End of the Fractions Phase Median M- COMP Score	End of the Integers Phase Median M- COMP Score	Weekly ROI from Baseline to End of the Integers Phase
Beauregard	12	25	32	2.22
Bob	24	30	32	.89
Lilly	24	31	35	1.22

Among the three lower performing students, weekly ROI on the M-COMP ranged from .89 to 2.22 points per week. The three lower performing students each demonstrated a higher weekly ROI than the AIMSweb® national normative average weekly ROI (.28 points per week). Furthermore, each of these students demonstrated a higher weekly ROI than the average weekly ROI of all study participants (.74 points per week). In addition to performance on the M-COMP, student performance on the Fractions-CBM and the Integers-CBM was also analyzed. Fractions-CBM data for the three lower performing

students is displayed in Figure 1. Integers-CBM data for the three-lower performing students are displayed in Figure 2.

Figure 1.

Fractions-CBM Data for Three Lower Performing Students

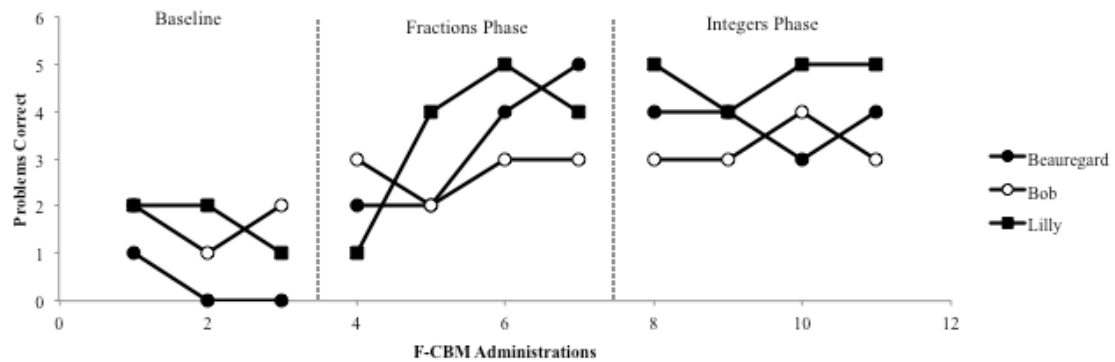
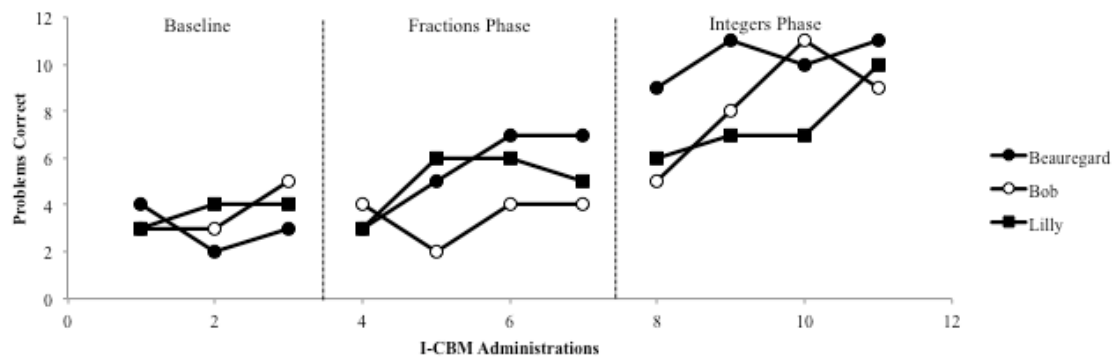


Figure 2.

Integers-CBM Data for Three Lower Performing Students



The Fractions-CBM data and the Integers-CBM data revealed that all three of the lower performing students demonstrated an improvement in fractions and integers computation skills during the intervention, in comparison to baseline. An investigation of the Fractions-CBM data indicates that the percentages of non-overlapping data points between baseline and the Fractions Phase for Beauregard, Bob, and Lilly were 100%, 75% and 75%, respectively. The percentages of non-overlapping data points between the

Fractions Phase and the Integers Phase for Beauregard, Bob, and Lilly were 0%, 25%, and 0%, respectively. This information indicates that student performance on the Fraction-CBM showed the greatest improvement during the Fractions Phase, which was the time period during which the PALS intervention focused on fractions computation skills. An investigation of the Integers-CBM data indicates that the percentages of non-overlapping data points between baseline and the Fractions Phase for Beauregard, Bob, and Lilly were each at 25%. The percentages of non-overlapping data points between the Fractions Phase and the Integers Phase for Beauregard, Bob, and Lilly were 100%, 100%, and 75% respectively. This information indicates that student performance on the Integers-CBM showed the greatest improvement during the Integers Phase, which was time period during which the PALS intervention focused on integers computation skills.

Discussion

The purpose of this study was to examine the effects of implementing a modified version of PALS with seventh grade students in regular education mathematics classes. More specifically, the researcher investigated the extent to which an adaptation of PALS for math, as a supplement to an existing curriculum, would result in a greater increase in math performance among seventh grade students, in comparison to having students complete math problem worksheets on their own. Furthermore, the study examined the extent to which lower performing and higher-performing students benefitted from the intervention.

In regard to the extent to which an adaptation of PALS for math resulted in an increase in math performance among seventh grade students, the PALS Group improved significantly when comparing the pre- and post-M-COMP scores, as well as the pre- and

post-Fractions-CBM scores within the group. This finding, which shows significantly improved mathematics computational skills within the group that received the PALS intervention, is consistent with findings among elementary-age PALS applications by Fuchs et al. (1995), Fuchs et al. (1997), Fuchs et al. (2001), and Fuchs et al. (2002). Furthermore, the PALS Group displayed a greater average weekly ROI on the M-COMP (1.05) than the AIMSweb® normative sample for this measure (.28), demonstrating major student growth in mathematics performance during the time that the PALS intervention was in place.

When comparing the post-Fractions-CBM scores of the PALS Group to the post-Fractions-CBM scores of the No-PALS group with an independent samples *t*-test, no significant differences between the two groups existed. Similarly, when comparing the post-M-COMP scores of the PALS Group to the post-M-COMP scores of the No-PALS group with an independent samples *t*-test, the PALS Group did not appear to differ significantly from the No-PALS Group. However, the ANCOVA result showed that when the students' M-COMP pretest scores were considered as covariates, the PALS Group students obtained statistically significant gains over the No-PALS Group. While the PALS Group's scores were not hugely different, their relative growth is consistent with prior research findings. Results from prior research have shown larger gains in students' scores, compared to the results obtained here.

One potential reason for this inconsistency with the existing literature on the efficacy of PALS may be related to the frequency of the intervention implementation. While the PALS intervention was implemented twice per week in the current study, as recommended in the PALS manual, Fuchs et al. reported that the intervention was

implemented three times per week in their 2002 study. An additional possible reason for the inconsistency with the existing literature on the efficacy of PALS may be related to the duration of the study. More specifically, the students in the current study received the intervention for nine weeks, whereas earlier studies ranged from 25-weeks (Fuchs et al, 1995), 18-weeks (Fuchs et al, 1997), 16-weeks (Fuchs et al., 2002), to 15-weeks (Fuchs et al, 2001). When considering the duration of the study as a possible reason for the inconsistency with the existing literature, a comparison of the average weekly ROI of the PALS Group on the M-COMP (1.05) to the average weekly ROI of the No-PALS Group (.41) suggests that more significant gains in mathematics computation may have been observed if the duration of the study had been extended.

In regard to the extent to which lower performing and higher-performing students benefit from the intervention, the existing literature suggests that both high-performing and lower performing students may benefit from the PALS intervention (Fuchs et al., 1995; Fuchs et al., 2001; Fuchs et al. 2002). When comparing these two groups, Fuchs et al. (1995) and Fuchs et al. (2002) indicated that while all students demonstrated increased learning outcomes, lower performing students demonstrated greater growth in comparison to the higher-performing students. The results of the current study were consistent with the existing literature and indicated that lower performing students demonstrated a greater average weekly ROI on the M-COMP (1.34) than the higher-performing students (.78). While the extent to which the lower performing and higher-performing students benefited from the intervention differed, both of these groups within the PALS Group demonstrated greater average weekly ROI growth in comparison to the AIMSweb® normative sample (.28). Additionally, the lower performing students in the

PALS Group demonstrated a greater weekly ROI on the M-COMP (1.34) than the lower performing students in the No-PALS Group (.79). Similarly, the higher-performing students in the PALS Group demonstrated a greater weekly ROI on the M-COMP (.78) than the higher-performing students in the No-PALS Group (.09).

Lower-achieving students likely benefit from the PALS intervention due to the high level of error correction and feedback they receive during the intervention. Higher-achieving students likely benefit from the PALS intervention due to the fact that the intervention requires them to create explanations about mathematical processes for their peers. The generative model of learning, which suggests that the retention of information is improved if the information is meaningfully related to previously learned knowledge, provides theoretical support for this hypothesis (Wittrock, 1989).

When examining the performance of the three lower performing students who were selected to participate in the nested within-subjects (i.e., ABC) case study analysis component of the study, the Fractions-CBM data and the Integers-CBM data revealed that all three of the lower performing students demonstrated notable improvements in fractions and integers computation skills during the intervention, in comparison to baseline. Additionally, the data indicated that student performance on the Fractions-CBM showed the greatest improvement during the Fractions Phase, which was the time period during which the PALS intervention focused on fractions computation skills. Furthermore, the data indicated that student performance on the Integers-CBM showed the greatest improvement during the Integers Phase, which was time period during which the PALS intervention focused on integers computation skills.

Beauregard, a seventh grade male student, obtained the lowest median M-COMP score among the three lower performing students during the baseline phase of the study. His median M-COMP score of 12 was at the 13th percentile, based on AIMSweb® national norms. His baseline scores on the Fractions-CBM were 1, 0, and 0 problems correct. His baseline scores on the Integers-CBM were 4, 2, and 3 problems correct. During the Fractions Phase of the study, when the students in the PALS Group received the PALS intervention with a focus on fractions, Beauregard demonstrated improved performance on the Fractions-CBM. By the end of the Fractions Phase, Beauregard's performance on the Fractions-CBM had increased to 5 problems correct. Furthermore, his M-COMP performance had increased from a score of 12 to a score of 25 by the end of the Fractions Phase. During the Integers Phase of the study, when the students in the PALS Group received the PALS intervention with a focus on integers, Beauregard demonstrated improved performance on the Integers-CBM. By the end of the Integers Phase, Beauregard's performance on the Integers-CBM had increased to 11 problems correct. Furthermore, his M-COMP performance had increased to a score of 32 by the end of the Integers Phase. By the end of the Integers Phase of the study, Beauregard had met the AIMSweb® 50th percentile goal for the spring benchmark period. Of the three lower performing students, Beauregard demonstrated the highest rate of improvement on the M-COMP, an average weekly ROI of 2.22 points per week. This weekly ROI is much greater than the AIMSweb® normative weekly ROI of .28 points per week.

Bob, a seventh grade male student, obtained a median M-COMP score of 24 during the baseline phase. His median score was at the 42nd percentile, based on AIMSweb® national norms, but much lower than his classroom peers who scored well

above the national norms. His baseline scores on the Fractions-CBM were 2, 1, and 2 problems correct. His baseline scores on the Integers-CBM were 3, 3, and 5. At the end of the Fractions Phase, Bob demonstrated only slightly improved performance on the Fractions-CBM, scoring 3 problems correct. At the end of the Fractions Phase, Bob increased his M-COMP score from 24 to 30. By the end of the Integers Phase, Bob's performance on the Integers-CBM had increased to 9 problems correct. His M-COMP score at the end of the Integers Phase was a 32, which is equivalent to the AIMSweb® spring benchmark 50th percentile. Bob demonstrated a weekly ROI of .89 on the M-COMP. While his weekly ROI was greater than the AIMSweb® normative ROI (.28), it was the lowest ROI of the three lower performing students. Additionally, his ROI on the M-COMP was lower than the PALS Group's average weekly ROI (1.05); however, his ROI was greater than the No-PALS Group's average weekly ROI (.41). Fractions seemed particularly difficult for this student and he appeared to need additional intervention in this area.

Lilly, a seventh grade female student, obtained a median M-COMP score of 24 during the baseline phase. This score was at the 42nd percentile, based on AIMSweb® national norms. Her baseline scores on the Fractions-CBM were 2, 2, and 1 problems correct. Her baseline scores on the Integers-CBM were 3, 4, and 4 problems correct. By the end of the Fractions Phase, Lilly demonstrated improved performance on the Fractions CBM, scoring 4 problems correct. At the end of the Fractions Phase, Lilly increased her M-COMP score from 24 to 31. By the end of the Integers Phase, Lilly's performance on the Integers-CBM had increased to 10 problems correct. Furthermore, her M-COMP performance increased to a score of 35 by the end of the Integers Phase.

By the end of the Integers Phase of the study, Lilly had met the AIMSweb® 50th percentile goal for the spring benchmark period. Lilly demonstrated an average weekly ROI of 1.22 points per week.

When the whole-class data are considered in conjunction with the improvement scores for the three lower performing students, the combination suggests that a seventh grade adaptation of PALS could be a useful intervention for lower performing students. The rates of gain observed in the PALS condition, as compared with national ROI data and the students in the control classroom, suggest that the PALS method could help seventh graders who are struggling in math to move toward, and even catch up to, end of year benchmarks.

Conclusions about the results of this study must be interpreted with caution, as several limitations to internal and external validity exist within the group design component of the study. In regard to internal validity, the study's participants were selected from previously assigned groups of students in two classrooms, thus random assignment was not used. In regard to external validity, the participants in the current study demonstrated higher baseline mathematics achievement on the M-COMP than the AIMSweb® national sample, suggesting that the students who participated in the study are not representative of a typical seventh grade classroom. Another potential limitation is the amount of work required to implement the adapted PALS. The researcher prepared all of the materials required for the PALS intervention (e.g., modification of materials, photocopying, organizing student folders) and classroom teachers may not have the time to do the same. This time factor suggests that conclusions about the feasibility of this intervention should be considered with caution.

When interpreting the results of the within-subjects case study component of this study, conclusions must be interpreted with caution, as limitations exist. The within-subjects ABC design is inferentially weak due to the fact that order effects are not controlled for when comparing the treatment conditions to the baseline condition. Direct comparisons among the phases cannot be made and carry-over effects may exist between the phases, which pose a threat to external validity. For example, classroom instruction, opportunities to practice, and the possibility of generalization may have played a role in student improvement in integer computation during the Fractions Phase. In future research, a return to the baseline condition between the Fractions Phase and the Integers Phase may provide the opportunity for stronger evidence that the treatment was responsible for improvement in student performance; however, it is likely that skill acquisition would confound the return to the baseline condition, as removal of treatment would not necessarily result in a return to baseline performance in mathematics computation.

Additional research should seek to explore the impact of this intervention on middle school students when the duration of the intervention is extended. Furthermore, additional research should seek to investigate the impact of this intervention with a more representative sample of seventh grade students. Future exploration of the social validity of this intervention among middle school students would provide additional information about student motivation and engagement.

Summary

Johns Hopkins University's Best Evidence Encyclopedia reports strong evidence for a variety of structured, cooperative, peer-based mathematics interventions, including:

CWPT, Student Teams Achievement Divisions, Team Accelerated Instruction (TAI) Math, and PALS (Johns Hopkins University, 2012). In an attempt to validate and expand the potential application of PALS for math in a wider variety of settings, this research study examined the effects of implementing a modified version of PALS with seventh grade students in regular education mathematics classes. The results of this study suggested that an adaptation of PALS for math for seventh grade students resulted in significant improvement in posttest mathematics computation performance within the PALS Group when their pretest M-COMP scores were considered as covariates. When comparing the performance of lower performing and higher-performing students, lower performing students demonstrated higher average weekly ROI in comparison to higher-performing students. The results of this study suggest that implementing an adaptation of PALS for math with seventh grade students systematically provides opportunities for all students to engage in mathematical computation practice and provides students with high levels of error correction and feedback. PALS for math provides educators with a supplementary intervention that helps to support groups of students with diverse levels of mathematics achievement.

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Appendix A

PALS for Math

Implementation Integrity Direct Observation Checklist

Teacher: _____ School: _____ Observer: _____

of Students: _____ Grade: _____ Date: _____

Lesson #: _____ Start Time: _____ End Time: _____

Directions: During the observation, place a checkmark in the “+” (or “-”) column for each step observed (or not observed). Tally the number of “+” and calculate integrity for each lesson part and overall integrity (see summary form at end of this sheet).

Note: If the step is not applicable, write N/A in the “+” column and do not include in the calculation of fidelity (for each part or overall total).

Part I: Introduction or Review of PALS Lesson

+	-	Step	Checklist
		1	Teacher reviews PALS rules with class (if necessary)
		2	Teacher introduces or reviews math concept
		3	Teacher reviews/demonstrates Coach's and Player's job (reminds students when to switch roles)
		4	Teacher reviews/demonstrates Question Sheet and Correction Procedure (if necessary)
		5	Teacher reminds students when to switch roles
		6	Teacher reminds students when to quit using Question Sheet and begin Self Talk
		7	Teacher names pairs and identifies first coaches

Number of +/7 = _____ % Introduction/Review Fidelity

Part II: PALS Coaching Activity (Student Behavior)

Pair One

+	-		Step	Checklist
			1	Coach draws circles around correct digits
			2	Coach uses correct error correction procedure when applicable (Coach tells Player the digit is incorrect and helps him/her correct mistake by providing an explanation but not telling the answer. Coach puts a triangle around that digit.)
			3	Coach uses Question Sheet for Row 1 (or until stop sign on Applications)
			4	Coach listens to Player self-talk for Row 2 (or until flag on Applications)
			5	Pairs switch roles
			6	Coach draws circles around correct digits
			7	Coach uses correct error correction procedure when applicable (Coach tells Player the digit is incorrect and helps him/her correct mistake by providing an explanation but not telling the answer. Coach puts a triangle around that digit.)
			8	Coach uses Question Sheet for Row 3 (or until stop sign on Applications)
			9	Coach listens to Player self-talk for Row 4 (or until flag on Applications)

Pair 1: Number of +/9 = _____% PALS Activity Fidelity

Part III: General Teacher Behaviors During Coaching

+	-	Step	Checklist
		1	Teacher monitors most pairs (most =80%; in a class of 20, 8 of 10 pairs) throughout the PALS lesson
		2	Teacher awards extra points to individuals and/or large group for good PALS behaviors
		3	Provides positive feedback to individuals and/or large group
		4	Provides corrective feedback to individuals and/or large group (as needed)
		5	Coaching lasts no more than 15 minutes

Number of +/5 = _____% General Teacher Behaviors Fidelity

Part IV: Practice Time

+	-	Step	Checklist
		1	Practice last no more than 5 minutes
		2	Students are engaged during Practice

Number of +/2 = _____% Practice Time Fidelity

*Part V: Practice and Wrap-Up**Pair Two*

+	-	Step	Checklist
		1	Students exchange papers
		2	Students write name in the "scored by" space
		3	During scoring, students circle correct problems, count number of correct answers, write at top of Practice Sheet, and return to partner
		4	Each partner marks 1 point on point sheet for each correct problem (mark individual points)
		5	Student pairs circle total number of points earned

Number of +/5 = _____% Practice and Wrap-Up Time Fidelity

Summary

Activity	Number of +	Total Number Possible	%
Introduction/Review		7	
Coaching Activity		9	
Teacher Behaviors During Coaching Activity		5	
Practice Time		2	
Practice & Wrap-Up		5	
<i>Overall PALS for Math Integrity</i>		28	

Appendix B

Implementation Integrity Direct Observation Checklist:**No-PALS Lesson**

Teacher: _____ School: _____ Observer: _____

of Students: _____ Grade: _____ Date: _____

Lesson #: _____ Start Time: _____ End Time: _____

Directions: During the observation, place a checkmark in the “+” (or “-”) column for each step observed (or not observed). Tally the number of “+” and calculate treatment integrity for each lesson component and overall integrity (see summary form at end of this document).

Note: If the step is not applicable, write N/A in the “+” column and do not include in the calculation of treatment integrity (for each part and the overall total).

Part I: Introduction of Practice Worksheet

+	-	Step	Checklist
		1	Teacher provides a practice worksheet to each student in the classroom.
		2	Teacher explains to the students that they are to work on the practice worksheets independently.
		3	Teacher explains to students they may raise their hands and ask for help if they need it.

Number of (+/3) x 100 = _____ % of Introduction of Practice Worksheet Fidelity

Part II: Practice Worksheet Activity

+	-	Step	Checklist
		1	Teacher provides help to students if students ask for help.
		2	Teacher collects Practice Worksheets as students complete the activity.
		3	If students are not done after 25 minutes, teacher collects all remaining worksheets.

Number of (+/3) x 100 = _____ % of Practice Worksheet Activity Fidelity

Summary

Activity	Number of +	Total Number Possible	%
Introduction of Practice Worksheet		3	
Practice Worksheet Activity		3	
Overall No-PALS Treatment Integrity		6	

BIOGRAPHY OF THE AUTHOR

Alexis Kiburis was born in Saratoga Springs, New York and received her high school diploma from Pinkerton Academy in Derry, New Hampshire. She graduated from the University of New Hampshire in 2007 with a B.A. in Psychology. Ms. Kiburis moved to Maine in 2007 and enrolled in the University of Southern Maine graduate program in School Psychology. In 2010, she earned her M.S. in Educational Psychology from the University of Southern Maine. Ms. Kiburis completed her pre-doctoral internship at the Sebago Educational Alliance Day Treatment Center. Her areas of interest include Multi-tiered Systems of Support (MTSS; Response to Intervention/RTI), empirically-based reading and mathematics instruction and intervention, as well as topics related to Curriculum-Based Measurement (CBM). She is currently a candidate for the Psy.D. degree in School Psychology from the University of Southern Maine in August, 2012.