ABSTRACT

WANG, JIAYI. An Analysis of Motivation Strategies Used within the Small-Group Accelerating Mathematics Performance through Practice Strategies (AMPPS-SG) Program. (Under the direction of Dr. John Begeny).

Mathematic skills are important for an individual’s academic success and overall wellbeing, but more than half of students in the USA perform below a proficient level in math. Although evidence suggests that intervention in elementary school is critical to supporting struggling learners, and there are several research-supported instructional practices to support students with math difficulties, the existing research is limited or has mixed findings with regard to the impact of motivational strategies designed to improve students’ math skills. The purpose of this study was to examine the effectiveness of specific motivational strategies used in the small-group Accelerating Mathematics Performance through Practice Strategies (AMPPS-SG) math intervention program. A multiple baseline design was used with three instructional groups of second grade students (eight total students) to compare the relative effectiveness of three different conditions on students’ math computation skills. Specifically, Condition 1 included all of the AMPPS-SG instructional components (e.g., timed calculation tasks, flashcard drill, error-correction procedures). Condition 2 included all instructional procedures used during Condition 1, as well as goal-setting, performance feedback, and reinforcement for performance. Condition 3 included all components used in Condition 2, as well as a group-based reward contingency for student effort and engagement. Results showed that students’ performance during Condition 3 was significantly better than performance during Conditions 1 and 2. Implications and limitations are discussed in terms of continued evaluation and possible benefits of AMPPS-SG and using motivational strategies during math intervention.
An Analysis of Motivation Strategies Used within the Small-Group Accelerating Mathematics Performance through Practice Strategies (AMPPS-SG) Program

by
Jiayi Wang

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APPROVED BY:

John Begeny
Committee Chair

Eui Kyung Kim

Scott Stage
BIOGRAPHY

Jiayi Wang was born in 1994 in Weihai, China. She went to pursue her bachelor’s degree in Beijing Language and Culture University in China in 2012 and she studied in Nottingham Trent University in England during the 2014-2015 school year as an exchange student. Following the graduation from Beijing Language and Culture University in 2016, she came to North Carolina State University and started graduate school studying in School Psychology program.
DEDICATIONS

I would like to dedicate this work to my parents, who are always unconditionally supportive of my study and life. I am extremely grateful for their love and comfort from the other half of the globe, and I also appreciate all the care that my grandparents as well as my uncles and aunts have given to me.
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Introduction

Achievement in mathematics has been correlated with several important life opportunities and experiences. Often it is described as an important correlate of employment within many fast-growing jobs (Stone, Alfeld & Pearson, 2008; Jones, 2014), but it is also positively associated with social and psychological well-being. For example, Bynner and Parsons (2006) found that poor numeracy is associated with lower self-esteem, higher level of depression, and more trouble with authorities. Despite its importance, many students experience challenges and difficulties in learning math. For example, only 40% of fourth graders in the USA performed at or above proficient levels on the National Assessment of Educational Progress (National Center for Education Statistics, 2015). It has been suggested that difficulties within math begin during primary school, and either stay stable or become worse throughout education (Kohli et al., 2015). Because achievement in mathematics is a significant mediator between first grade math competences and third grade math skills (Fuchs, Geary, Fuchs, Compton & Hamlett, 2014), the second year of primary school is arguably a critical period for students to strengthen their foundational math skills.

Effective Math Intervention Components and Practices

Fortunately, existing scholarship offers guidance about effective components of math instruction and intervention for elementary-aged students. A thorough search for meta-analyses and comprehensive literature reviews evaluating math instruction and interventions identified several relevant publications over the past ten years. What follows is a summary of the reviews and meta-analyses that are most relevant to the present study, based on the student populations, dependent variables, and/or instructional components evaluated in those review studies.
Of the interventions targeting students’ math computation (e.g., addition or subtraction), instructional components such as drill and practice, modeling, speeded practice (speed-based intervention and explicit timing), using flash cards, and combining two or more intervention components are all reported to have high effect sizes for students with low math achievement or learning difficulties. For example, Codding, Hilt-Panahon, Panahon, and Benson (2009) conducted a meta-analysis on math computation interventions and reviewed 37 studies from 1980-2007, representing 914 K-12 students with mathematic computation difficulties. Using flash cards with computation questions yielded one of the largest effect sizes ($d = 1.12-2.58$). Conversely, the explicit timing intervention requiring students to complete as many problems as possible in one minute had mixed results ($d = 0.20-1.14$); with explicit timing, the largest effect sizes were with improving computation rate and were smaller for computation accuracy.

In another meta-analysis, Codding, Burns, and Lukito (2011) reviewed 17 single-case design studies on mathematics basic-fact fluency interventions with 55 students between grades 1 and 6, all of whom experienced math learning difficulties. Intervention components were categorized into four types of instructions: drill, practice with modeling, practice without modeling, and self-management. Drill and practice are fluency-building approaches that are summarized by Fuchs et al. (2008) as one of the seven principles of effective intervention for students with mathematics disabilities. The difference between drill and practice is that drill is the rehearsal of isolated items recently learned (e.g. flash cards), whereas practice targets employing recently learned skills in a different context (e.g. word problems) that are usually combined with previously learned skills (Haring & Eaton, 1978). In the Codding et al. (2011) study, modeling was generally considered as a process where a teacher demonstrates step-by-step how to solve a math problem with one or more students. One key finding of their meta-
analysis showed that drill ($\Phi = .92$) and practice with modeling ($\Phi = .71$) were highly beneficial for students, and integrating three or more intervention components was also well-supported ($\Phi = .68$), compared with intervention with less than three components ($\Phi = -.08$). In a similar meta-analysis, Methe, Kilgus, Neiman, and Riley-Tillman (2012) looked at 11 single-case designs on K-6 students with math achievement problems or specific learning disabilities. Consistent with the previous two studies, Methe et al. found a large effect size in speed-based interventions (Improvement rate difference; $IRD = 0.97$), such as a one-minute calculation “sprint” or cumulative review flash-card drill. Support was also found for combining two or more intervention components ($IRD = 0.65$).

In addition to the three aforementioned meta-analyses that examined the effects of intervention strategies on students’ computation skills, other meta-analyses (Swanson, 2009; National Math Advisory Panel [NMAP], 2008; Dennis et al., 2016) reviewed interventions targeting general math competence in a variety of domains, such as computation, operations, word problems, fractions, algebra, etc. In these meta-analyses, two types of instruction—explicit instruction and strategy instruction—were found to have a large effect size on students’ math achievement. Explicit instruction generally involves teachers using step-by-step modeling of how to complete specific math problems, as well as teachers providing guided practice opportunities, cumulative review, and corrective feedback on the set of math problems (NMAP, 2008; Gersten, Chard, et al., 2009; Codding, Volpe, and Poncy, 2017). Strategy instruction focuses on teachers modeling general problem-solving heuristic strategies, as well as reminding students to apply and self-evaluate the use of those strategies (Swanson, 2009; Codding, et al., 2017). Swanson (2009) reviewed 28 studies that included primarily elementary-aged students with math learning difficulties. The mean effect size of studies that integrated both explicit
instruction and strategy instruction was larger ($d = 0.58$) than studies that only used explicit instruction ($d = 0.48$), only used strategy instruction ($d = 0.32$), or used neither ($d = 0.26$). Explicit instruction was also shown to be effective in two other review studies (NMAP, 2008; Dennis et al., 2016). Based on 26 studies examining instructional approaches for students with math learning difficulties or a math disability, the NMAP (2008) suggested that explicit instruction improves students’ skills with word problems and computation. Most recently, Dennis and colleagues (2016) found that explicit teacher-led instruction had a large effect size ($g = .82$), but it was more effective for elementary students ($g = .57$) than kindergarten students ($g = .30$).

Two additional review studies are pertinent to the present study because they found supportive evidence for other math intervention strategies not previously described. Specifically, Gersten, Chard et al. (2009) synthesized math intervention studies from 1971 to 2007 for school-aged students with a math learning disability and found support for explicit instruction ($g = 1.22$) and having students verbalize their reasoning aloud when solving math problems ($g = 1.04$). This study also found positive effects for students that used visual representations during math problem-solving ($g = 0.46$), an approach that helps students link the relationship between quantitative information in math problems with symbolic mathematical operations (e.g., ten frames, number lines, percent bars). In many ways, the Institute of Educational Science Practice Guide (Gersten, Beckmann, et al., 2009) for K-8 math interventions summarizes the findings from the aforementioned meta-analyses. For example, the Practice Guide recommends that “instruction during the intervention should be explicit and systematic [and should] include providing models of proficient problem solving, verbalization of thought processes, guided practice, corrective feedback, and frequent cumulative review” (P.6). Another recommendation,
which was found to have moderate evidence for support, suggests that students should work with visual representations of mathematical ideas.

**Motivational Components with Unknown or Inconsistent Effects**

Although the instructional approaches and components described above (i.e., explicit instruction, strategy instruction, speeded practice, drill and practice, modelling, flash cards, verbalizing thoughts, and visual representation) have relatively compelling evidence of effectiveness when used with students with a math disability and/or those who struggle to learn math foundational skills, there are still several unanswered questions within the math intervention research. Most notably, the research related to motivation and its impact on math performance is still unclear. For example, the NMAP (2008) indicated that students who believe that effort is essential when learning math achieved higher math performance than those who believe math is an innate ability, and that students’ beliefs can be changed through motivational strategies. In addition, students with a math disability usually suffer from low motivation and under-developed self-regulation skills, which might compromise their math performance (NMAP, 2008; Montague, 2007; Swanson & Jerman, 2007). As a result, motivational strategies are recommended to help students understand the importance of effort in learning math and improve their skills. However, evidence supporting motivational strategies during math intervention is currently considered low (Gersten, Beckmann, et al., 2009).

Researchers have studied several different strategies for improving students’ motivation. Some promising components among them include performance feedback with goal-setting, reinforcement contingent on performance, and group reinforcement for effort and engagement. Based on previous work (e.g., Codding, Chan-Iannetta et al., 2009; 2011), performance feedback with goal-setting is mainly composed of the following steps: (a) having the student mark his or
her responses with a given answer key after a brief math assessment, (b) calculating the student’s score and recording it on a graph, (c) showing the student (using the graph) how the score improved (when applicable), and (d) encouraging the student to beat his or her previous score during the next assessment. With a sample of third grade students, Fuchs et al. (2003) reported a positive effect for a math intervention involving a self-regulated learning strategy that incorporated goal setting and self-evaluation. However, calling into question the effectiveness of goal-setting during math interventions, Gersten, Chard et al. (2009) found a statistically significant but low effect size for using feedback and graphs of students’ performance ($g = .23$), and a low and statistically insignificant effect size ($g = .17$) for using goal setting with assessment of progress toward that goal.

Another motivational strategy often used within academic interventions is reinforcement (e.g., using verbal praise and/or small, tangible rewards contingent upon performance). Swanson’s (2009) meta-analysis only found that 4 of 28 studies evaluated reinforcement as a math intervention component using a group design for students with a math disability, and only one study yielded a high effect size in improving students’ mathematic performance. In contrast, Codding, Chan-Iannetta et al. (2011) found that when performance feedback with goal setting and reinforcement was added to the Kindergarten Peer-Assisted Learning Strategies math intervention, students responded better in early numeracy performance compared to receiving the intervention without these motivational components. A meta-analytic review (Codding, Hilt-Panahon, et al., 2009) that examined goal-setting yielded a large range of effect sizes on math fluency with K-12 students with math difficulties ($d = 0.19-1.2$), with higher effect sizes reported from goal-setting that was combined with contingent reward, and lower effect sizes with non-contingent reward conditions.
Reinforcement based on effort and engagement (rather than performance) also has preliminary evidence of being an effective component of a math intervention. Because on-task behavior is generally incompatible with problem behavior (Ducharme & Shector, 2011), and students’ attention in class has been reported to be the most robust predictor of their math performance in first grade (Fuchs et al., 2005), student on-task behavior is indicated to positively affect academic performance. Providing students with feedback about effort also appears to lead to higher self-efficacy and better math subtraction skills in students with learning disabilities (Shunk & Cox, 1986). Some studies have also examined the effects of feedback for effort when used in an interdependent group contingency (i.e., a small reward is provided to all participants in the group when the collective on-task behavior meets a pre-specified criterion). A meta-analysis on group contingency procedures to improve targeted behavior for school-aged students found an effect size of 2.88 for interdependent group contingencies (Little, Akin-Little, & O’Neill, 2015). However, group contingencies in the vast majority of studies are applied to whole-class instruction and no known studies have specifically evaluated group contingencies with small instructional groups of 3-6 children in the primary grades.

**Research Questions and Purpose of the Present Study**

As noted previously, math achievement is essential in the early grades but a large percentage of US students do not have proficient or even basic math skills by fourth grade. Existing research suggests that instructional components such as explicit instruction, strategy instruction, opportunities for practice, and visualization can meaningfully improve students’ math ability. Some suggest that motivational strategies should be integrated within math instruction for struggling learners, but additional research is needed to examine specific strategies designed to enhance students’ motivation during math instruction (e.g., goal-setting,
reinforcement for performance improvements, and contingencies to promote effort and engagement for students in small instructional groups). From the existing research base and gaps within it, the central purpose of this study was to examine the relative effectiveness of three different intervention conditions. Condition 1 included several evidence-based instructional practices designed to improve math computation skills for elementary-aged students. Condition 2 included the same evidence-based instructional practices from Condition 1, in addition to (a) performance feedback with goal setting and (b) reinforcement for improved math performance. Condition 3 included the same instruction and motivational components used in Condition 2, as well as group contingency for effort. Our two primary research questions were as follows:

1. Is Condition 2 more or less effective than Condition 1 and Condition 3?
2. Is Condition 3 more or less effective than Condition 1 and Condition 2?

To answer these research questions, we examined the relative effectiveness of these intervention conditions with small groups of second grade students with math difficulties. Based on the evidence supporting each of the aforementioned intervention components, it was hypothesized that Condition 2 would be more effective than Condition 1, but Condition 3 would be more effective than Condition 2. Finally, as a supplemental and exploratory research question (RQ), we asked in RQ3: did participants show meaningful improvements in math computation fluency over the duration of the project? RQ3 was a supplemental research question because although we were interested in evaluating participants’ growth over the duration of the project, our choice of experimental design was best fit to address RQ1 and RQ2, and (for reasons described later) it only provided preliminary understanding about RQ3.
Method

Participants and Setting

Participants originally included nine second grade students from one urban elementary school located in the southeast USA (as discussed later, one student moved to another school during the beginning of the project, resulting in eight total participants). Participants were selected using the following procedures. First, as part of the standard assessment procedures in the participating school, all students (N = 58) from the three different second grade classrooms received winter benchmark assessments using the AIMSweb Mathematics-Concepts and Application (Person Education, 2012; M-CAP) and the AIMSweb Mathematics-Computation (Person Education, 2012; M-COMP) measures. All students who scored below the 50th percentile on the M-CAP and M-COMP (n = 19) were then further assessed with Mathematics Computation Curriculum-Based Measures (Shinn, 2004; M-CBM) to determine each student’s instructional level (Shapiro, 2011) on three different two-by-one digit M-CBM probes: addition, subtraction, and mixed addition-subtraction. From this assessment, any student who scored at a mastery or instructional level on all three probes (n = 1) or at a mastery level on the addition probe (n = 4) were excluded from the study because they had computation skills that were strong enough not to need the type of intervention support offered as part of this study. Of the 14 students who remained eligible for participation, we sought to develop three instructional groups of three students each. Students who performed similarly on each of the three M-CBM probes were considered to have relatively homogenous skill levels and were randomly assigned to an instructional group of students with similar math abilities. Of these nine participants, all were at the instructional level with the addition probe. With the subtraction probe, seven were at a frustrational level and two were at an instructional level; with the mixed probe, five were at a
frustrational level and four were at an instructional level. Unfortunately, one student moved within a couple weeks of the project starting, leaving eight participants in total. Group and student participants are identified through number. Specifically, Group 1 includes Students 1, 2 and 3; Group 2 had Students 4, 5, and 6; and Group 3 had Students 7 and 8.

Of these eight participants, none were receiving special education or English as a Second Language services; six were female, two were Black, three were Latino, and three were White. Due to school district policies, we could not obtain information about an individual student’s eligibility for free or reduced-price lunch, but at the participating school, 35% of the students were receiving free or reduced-price lunch.

Interventionists included three undergraduate students and two graduate students, each of whom were trained to implement the instructional and motivational procedures described later. Specifically, each interventionist was first shown how to implement the full implementation protocol from an interventionist who had previously implemented the protocol with perfect integrity for several months. Interventionists then practiced implementation and received feedback from the experienced interventionist, and then each interventionist implemented the full protocol at least two consecutive times to ensure 100% integrity on both the core implementation procedures and the tips/reminders checklist (described later). All interventionists were required to meet this criterion before being able to implement the protocol with a student participant, and implementation integrity with student participants was continuously monitored (also described later). All intervention sessions were conducted in a room within the participating school that was free from noise and distractions.
Measures

Mathematics-Concepts and Application (M-CAP). Provided by AIMSWeb, a web-based assessment system supporting universal screening and progress monitoring for grades K-12, M-CAP is an 8-minute test assessing students’ general mathematic problem-solving skills, including domains of number sense, operation, measurement, and patterns and relationship. When scoring M-CAP, a score of 1, 2 or 3 is given to students for correct responses, and a score of 0 for incorrect responses. The criterion validity ranged from .63 to .67 when correlated with the third grade North Carolina End of Grade Test, and the alternate form reliability is .86 for second grade (Pearson Education, 2012).

Mathematics-Computation (M-COMP). M-COMP from AIMSWeb is consistent with M-CAP, in terms of test format, test time, and scoring rules. As for the content, the M-COMP test is composed of 28 items of addition and subtraction problems to examine whole number operation skills. Alternate form reliability of the M-COMP was .82 for second grade (Pearson Education, 2012). Using the Group Mathematics Assessment and Diagnostic Evaluation, the criterion validity coefficient of M-COMP ranged from .73 to .84 (Person Education, 2012).

Mathematics Computation Curriculum-Based Measurement (M-CBM). M-CBM (Shinn, 2004) is a timed test with 84 math computation problems (items), with numerals per item ranging from 0 to 20. Students are asked to answer as many problems as they can within 2 min. Digits correct per minute (DCPM) is calculated by dividing a student’s number of correct digits written by two. Estimates of M-CBM inter-scorer agreement is .83 and alternate form reliability is .91 (Shinn, 2004). Validity coefficients range from .40 to .80 across types of CBM of math(Christ, Scullin, Tolbize & Jiban, 2008; Foegen, Jiban, & Deno, 2007).
As was described earlier, M-CBM benchmark probes were used for screening purposes and determining homogenous instructional groups. They were also used for pre-post assessment. Students’ scores on the three M-CBM benchmark probes gathered for screening and grouping purpose constituted as pre-assessment data. Post-assessment data were gathered by administering the same three benchmark probes the day after the last intervention session. In addition, M-CBM progress monitoring probes were used in the study to compare students’ performance across the different experimental conditions. During intervention phase, students were given a M-CBM progress monitoring probe at the end of the intervention session on every Tuesday and Thursday. Each group’s median score per assessment session served as the primary dependent variable within the multiple-baseline design.

**Instructional Procedures**

Each instructional session lasted approximately 25-30 minutes and instructional sessions were implemented 2-3 times per week for 14 weeks. All participants received instructional procedures that are included as part of the Accelerating Mathematics Performance through Practice Strategies math intervention program (Codding & Begeny, 2018) for small groups (AMPPS-SG). The overall goal of AMPPS-SG is to improve whole number knowledge, including computation and word problem solving, for elementary-aged students with low achievement in mathematics. AMPPS-SG was designed as a Tier-II intervention to be implemented in a small group of two to four students. The instructional curriculum used in AMPPS-SG is divided into five units, each containing three lessons, beginning with simple addition, followed by basic subtraction, a review unit of basic facts (addition and subtraction), an introduction to fact families, and lastly a unit containing more complex addition and subtraction problems through 20. One lesson is implemented per instructional session. AMPPS-SG
instructional components include the following evidence-based strategies: modeling, corrective feedback, guided practice with story problems, explicit timing, and flash card drills (e.g., Codding et al., 2011). Implementation of these instructional components also allowed students to use visual representations of number relationships, such as using ten frames, number lines, and drawings (Gersten, Chard et al., 2009). Summarized below are the primary instructional procedures and materials used in AMPPS-SG.

An AMPPS-SG intervention session starts with students completing a worksheet of computation problems that are relevant to the lesson for that day. Students are timed for one minute and we henceforth refer to this initial timed task as Sprint #1. Students’ performance on Sprint #1 is also used to determine whether students move on to the next lesson in the AMPPS-SG curriculum. Specifically, using criteria described by Burns, VanDerHeyden, and Jiban (2006), if the group of students’ median score is 17 DCPM or higher and 2 digits incorrect per minute (DIPM) or less, students move to next lesson and start with a new Sprint #1 that corresponds with the new lesson. If these criteria are not achieved, the group continues to receive practice with similar computational problems they practiced in the previous lesson.

After Sprint #1, practice strategies within the AMPPS lesson includes the following activities, in order (a) guided practice on specific math facts (determined according to the unit and lesson for the day) through verbal rehearsal or visual representation; (b) word problem-solving while also using a ten frame (i.e., the interventionist models problem-solving of a word problem by thinking out loud and visualizing on a ten frame, then students are instructed to use this same strategy while solving a word problem on their own); (c) three-minute cumulative review (i.e., students responded orally to flash card drill in a round robin format where students in the group are randomly and individually selected to respond); (d) completion of Sprint #2 (i.e.,
students complete a math computation sheet of the same problems completed in Sprint 1 but arranged in a different order on the page); and (e) each student scores his or her own Sprint #2 paper as the interventionist reads the correct answers.

**Experimental Design and Conditions**

A multiple baseline experimental design across three instructional groups was used to evaluate the effectiveness of each experimental condition and allowed for an evaluation of RQ1 and RQ2. Multiple baseline design has several advantages over other experimental designs in this study. For example, it is free of practical and ethical concerns associated with an ABAB design, where there is a withdrawal of intervention or a control group where participants with math difficulties would not be able to receive potentially beneficial intervention. In addition, multiple baseline design is efficient in demonstrating the effect of intervention by examining the change of data points after a new condition introduced to the first group and the replication of data changes at different time points in other groups (Kazdin, 2011). Each experimental condition in this study is described next.

**Condition 1.** In Condition 1, student participants received each of the AMPPS-SG instructional components (as previously described).

**Condition 2.** In this condition, students received each of the AMPPS-SG instructional procedures used during Condition 1 in addition to (a) performance feedback with goal setting and (b) reinforcement for improved math performance. Performance feedback with goal setting involved the interventionist graphing each instructional group’s median score on the Sprints, and encouraging all students to reach the group goal (i.e., at least 17 DCPM and 2 or less DIPM) in Sprint#1. During each instructional lesson, each student was also encouraged to obtain more DCPM during Sprint #2 compared to his or her Sprint#1 score. Reinforcement for improved
math performance involved a Star Chart and Prize Box, which were used consistent with past research (e.g., Mitchell & Begeny, 2014; Begeny, 2011). More specifically, each group would earn one star for meeting the group goal in Sprint#1 and another star for increasing the group median score from Sprint#1 to Sprint#2. When the group of students earned 15 total stars (i.e., completed one row on the Star Chart), each student could select a small, age-appropriate prize from the prize box (e.g., a pencil or eraser).

**Condition 3.** In Condition 3, all procedures from Condition 2 were used, but students also received a group contingency for effort. Specifically, the You/Me game was introduced to students, in which students could earn points for their on-task behaviors (e.g., following the interventionist’s instructions during the lesson), while the interventionist could earn points if students did not show on-task behaviors. At the end of the lesson, the student group could earn an additional star for winning the game and another star for winning by more than 5 points.

**Procedural Integrity and Inter-scorer Agreement**

Procedural integrity was evaluated by a second member of the research team who was also trained to use all the previously described procedures. The observer examined the interventionist’s use of the core procedures involved with each condition (e.g., 13 steps for Condition 3) as well as implementation quality factors and steps referred to as tips and reminders (e.g., 45 tips and reminders during Condition 3). All interventionists were regularly observed and a total of 32.6% of the sessions were observed for procedural integrity. Across all observations, an average of 100% of the core procedures and 98.7% of the tips and reminders were implemented with fidelity.

One-hundred percent of students’ progress monitoring probes were double-scored for inter-scorer agreement by having an independent member of the research team score the probes
for DCPM and DIPM. Inter-scorer agreement was calculated by dividing the number of agreements on DCPM by the number of agreements plus disagreements and multiplying by 100. Mean agreement for progress monitoring probes was 98% (range = 82%-100%).

**Data Analysis Strategy**

To determine if students’ math computation performance improved as a function of receiving the math intervention, and to compare effectiveness of motivational strategies used in Condition 2 and Condition 3, median group scores of DCPM and DIPM in progress monitoring assessments across three conditions were graphed by small group. Visually analyzing these data within and between groups served as the primary analysis, and Tau effect sizes were computed as a secondary analysis. Despite many effect size methods available for single-subject designs, visual analysis is still the most commonly used and approved method for single-subject designs (Kazdin, 2011; Kratochwill et al., 2010). Consistent with recommended practice for analyzing data from single-subject designs, group median scores were examined according to six different features: (a) level, (b) trend, (c) variability, (d) immediacy of effect, (e) overlap, and (f) consistency of data patterns (Kratochwill et al., 2013).

Tau effect size were computed as a secondary analysis instead of percent of non-overlapping data (PND), because Tau (a) takes both trend and nonoverlapping data into account, (b) can identify and accommodate baseline trend if it exists (i.e., Tau-U), (c) is ideal for smaller datasets, and (d) correlates well with other nonparametric indices (Parker, Vannest, Davis, & Sauber, 2011; Vannest, Parker, Gonen, & Adiguzel, 2016). Tau, rather than Tau-U, was calculated in this study because there were no obvious baseline trends demonstrated in this dataset (i.e., there were no significant baseline trends; Parker, Vannest, & Davis, 2011). Tau is the percentage of nonoverlap minus overlap, and is a proportion that ranges between -1 and 1.
Vannest and Ninci (2015) suggest the following interpretation guidelines for Tau coefficient sizes: “[a] 0.20 improvement may be considered a small change, 0.20 to 0.60 a moderate change, 0.60 to 0.80 a large change, and above 0.80 a large to very large change” (p. 408). A web-based application developed by Vannest and colleagues was used to calculate Tau effect size coefficient between (a) Condition 1 and Condition 2, (b) Condition 2 and Condition 3, and (c) Condition 1 and Condition 3. The web-based calculation provides effect size coefficients and corresponding $p$-values that indicate if there was a statistically significant performance improvement across conditions.

As a supplemental analysis to help examine overall growth in students’ math skills across the 14-week project, differences between pre- and post-assessment of three M-CBM benchmark probes were analyzed by comparing each student’s expected growth to their actual growth. Expected weekly growth on M-CBM measures for second grade students has only been reported in two prior studies (Fuchs, et al., 1993; Keller-Margulis, Mercer, & Shapiro, 2014). Fuchs et al. (1993) found that .30 DCPM represented the weekly rate of improvement and Keller-Margulis et al. (2014) found a rate of .14 DCPM per week. In our study, we applied the findings from Fuchs and colleagues (1993) in order to use a more challenging criterion to evaluate potential improvement on M-CBM.

**Results**

**Visual Analyses**

Figure 1 provides group median DCPM for each group across three conditions. The small number of missing data points for Group 3 simply reflects student absences during those assessment sessions. For group 1, the performance in Condition 1 started with slight variability but stabilized at the last two assessment sessions with a group median near 20 DCPM. During
Condition 2, the median level of performance was similar to Condition 1, with a sharp increase during the last assessment. Condition 3 demonstrates a generally higher level of DCPM with a slightly increasing trend. For group 2, students’ median DCPM during Condition 1 were initially variable, but stabilized during the last three assessment sessions. During Condition 2, performance was generally stable and at a level similar to Condition 1. At the beginning of Condition 3, there was a relative immediate increase, and then a slightly increasing trend over time with some variability. For group 3, performance during Condition 1 was mostly stable at around 15 DCPM and it remained relatively stable at that level during Condition 2. At the beginning of Condition 3, students’ level of performance increased after the first assessment session and remained at a higher level than earlier conditions, but with some variability and an increasing trend. Overall, visual analyses suggest that students’ performance during Conditions 1 and 2 were generally similar, with Condition 2 showing only slightly better DCPM performance. In contrast, Condition 3 evidenced higher levels of performance than Conditions 1 and 2. Descriptive data also reveal this pattern. For example, across all students, the average scores for Conditions 1, 2, and 3 were 17.6, 20.3, and 27.1, respectively.

**Tau Analyses**

Table 1 represents the tau effect size comparisons across each condition: (a) Condition 1 compared to Condition 2, (b) Condition 2 compared to Condition 3, (c) Condition 1 compared to Condition 3. Both individual group effect size and the weighted average of effect size across the three groups are provided in the table. Comparing Condition 1 and 2, tau coefficient sizes indicated a moderate improvement in all three groups when performance feedback with goal setting and reinforcement for performance were added to AMPPS-SG instructional components (range = .23-.38). However, the effect sizes were not statistically significant. When comparing
Conditions 2 and 3, tau effect sizes were large and statistically significant for each group and across all groups—each evidencing higher DCPM during Condition 3, suggesting that the group contingency for effort significantly improved median scores for each group. Comparisons of Conditions 1 and 3 likewise evidenced significantly higher DCPM scores during Condition 3, with effect sizes even larger than when comparing Conditions 2 and 3.

**Pre- and Post-assessment Analyses**

Table 2 provides individual student’s scores on the three M-CBM benchmark probes (addition, subtraction, and mixed addition-subtraction combined) in pretest and posttest, respectively. According to Fuchs et al. (1993), the weekly expected rate of improvement for first grade to third grade students is .30 DCPM. Thus, across 14 weeks of the intervention study, student participants would be expected to increase 4.2 DCPM. Table 2 shows that seven students exceeded expected performance on at least one of the three M-CBM assessments, and six of the students did so for all three assessments. Only Student 6 did not make meaningful progress on any of the three probes. Overall, the pre- and post-assessment analyses indicate that the majority of students benefited from receiving the various instructional and motivational components that were integrated throughout the project.

**Discussion**

The primary purpose of this study was to examine the relative effectiveness of specific motivational strategies found in the AMPPS-SG intervention with elementary school students, including performance feedback, goal setting, reinforcement for performance, and group-based reinforcement for effort and engagement. The rationale for this study was influenced by the following: (a) math proficiency is important for students’ overall success, but less than half of fourth-grade students in the US are performing at a proficient level; (b) second grade is a critical
time period to support students struggling with math; and (c) there is minimal research about math intervention programs for elementary-aged students in general, and even less research examining the potential impact of motivational strategies to enhance success in math. Overall, this study showed that although the motivational strategies of goal setting, performance feedback, and performance reinforcement in Condition 2 did not yield a significantly higher performance of DCPM than Condition 1, the integration of these motivational strategies—when combined with group-based reinforcement for effort in Condition 3—significantly improved students’ performance in math computation, as indicated by both visual analyses and large tau effect sizes. Our pre-post assessments also showed that, during the project time period, seven out of eight students demonstrated improvements beyond what past studies have described as expected growth for second grade students on M-CBM measures.

The lack of statistically significant effects of performance feedback, goal setting and performance reinforcement in Condition 2 is not consistent with our hypothesis, but it is not inconsistent with some prior research. Although motivational strategies are recommended by the NMAP (2008), some studies did not find significant effect sizes for strategies such as goal setting with an assessment of progress toward the goal (Gersten, Chard, et al., 2009) or reinforcement/rewards during math intervention (Swanson, 2009). However, the significant effect of combining group-based reinforcement for effort, performance feedback, performance reinforcement, and goal setting appeared to be commensurate with evidence suggesting the overall importance of motivational strategies, especially strategies to raise students’ attention and effort (Shunk & Cox, 1986; Fuchs et al., 2005). A study related to mindset theory reveals that, with an equal beginning, students given praise for their effort (e.g. “you work so hard”) showed better performance in later IQ tests, whereas the performance plummeted among students given
praise on their ability (e.g. “you are so smart”). In addition, students praised for their efforts are more likely to have a growth mindset, which is often correlated with more willingness to take challenges and higher chances of improvements (Dweck, 2006). Motivation strategies are particularly needed for math fluency intervention in that fluency building often requires extensive practice, and that students with low motivation would lose interest easily and thus benefit less from the intervention (Foster, 2018). Related to this concern, motivators to help students regulate their attention and behaviors to work hard is considered as one of the seven principles of effective interventions for students with math disabilities (Fuchs et al., 2008).

Implications for Practice

Given the evidence of significant effectiveness of the integrated motivational strategies in improving students’ math computation fluency, teachers should be reminded of the importance of raising and maintaining students’ motivation, especially for students with difficulties or minimal interest in math. Applicable strategies might include setting a goal for students before they begin on their practice or task, graphing their performance and progress on a chart, providing positive feedback or rewards for their improved task performance, and more importantly, for their on-task behaviors and engagement. In spite of the importance of providing feedback, teachers might find it challenging to give attention and feedback to every student in classroom settings. As a result, when working with a group or the whole class, interdependent group contingencies for engagement might be more applicable, as this approach helps teacher to manage on-task behaviors by making every student responsible for their collective engagement (Weis, Osborne, & Dean, 2015). For example, the teacher can give points to the whole group when they notice one of the group members exhibits on-task behavior or take off group points when they see a member off-task.
Additionally, our study also provides evidence of the potential benefits of AMPPS-SG for second grade students with low achievement in math. This is particularly promising because there are relatively few small-group interventions available that target early elementary-aged students’ computational fluency and compared with a one-on-one intervention, a small-group intervention is more time- and recourse-efficient. Furthermore, this study suggests that even educators with little to no teaching experience (e.g., university student volunteers) are capable of learning and implementing the program with strong fidelity. For schools looking to maximize resources, there are clear advantages of utilizing evidence-based programs that can be feasibly implemented by adults with varying levels of teaching experience.

**Limitations and Future Research Directions**

As a preliminary study of the AMPPS-SG program, there are several limitations of our study, which we hope will encourage further investigation in future research. First of all, as part of our experimental design, group-based reinforcement for effort was added during Condition 3 to other motivational strategies (i.e., goal setting, performance feedback, and reinforcement for performance from Condition 2). Thus it is not very clear whether the significant improvement in Condition 3 is caused by the integration of all motivational strategies, or only the group-based reinforcement for effort and engagement alone. To disentangle the unique impact of different types of motivational strategies, future research could evaluate, for example, the impact of only using group-based reinforcement for effort compared to its impact when combined with other motivational strategies. Another limitation is related to the lack of baseline data of students’ general math computation performance before participating in AMPPS-SG intervention, which prevents us from identifying the effect of AMPPS-SG instruction compared to no instruction. Future studies could examine the overall effect of the full set of AMPPS-SG instructional and
motivational procedures through single-case experimental designs or through randomized controlled experiment with comparisons between the intervention group and control group. A third limitation lies in the assessment measures used in this study. Given that there is no updated national norms available for the rate of improvement with M-CBM, the pre-post assessment results using M-CBM should be interpreted with that caveat. Future researchers conducting pre-post assessment might consider other measures that have national norms. In addition, to comprehensively examine the effectiveness of AMPPS-SG, future research could also include other measures (e.g., math concepts and application) in addition to math computation, and multiple assessments could be conducted a few weeks/months after the project to identify potential effect of maintenance.

**Conclusion**

This study examined the effectiveness of motivational strategies of performance feedback, goal setting, reinforcement for performance, as well as group-based contingency reinforcement for effort and engagement when they are used in a small group math intervention with second-grade students. The results showed that interdependent group contingency to reward effort and engagement significantly improved students’ math computation performance, emphasizing the importance of students’ motivation to stay on-task during math fluency instruction. In addition, this study also preliminarily explored the overall effect of AMPPS-SG on student’s math computation performance. Results revealed meaningful improvement in students’ computation scores compared to their pre-test scores, indicating a potential benefit of the AMPPS-SG intervention. Future studies are needed to continue examining the effects of AMPPS-SG and to further examine the effectiveness of specific motivational strategies during instruction designed to improve computational fluency.
References


Jones, J. I. (2014). An overview of employment and wages in science, technology, engineering, and math (STEM) groups. *Between the Numbers, 3*, 1-4.


Table 1

*Tau Analyses of Group Median Comparison between Conditions*

<table>
<thead>
<tr>
<th>Group</th>
<th>Condition 1 vs Condition 2</th>
<th>Condition 2 vs Condition 3</th>
<th>Condition 1 vs Condition 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.23</td>
<td>.73&lt;sup&gt;a&lt;/sup&gt;</td>
<td>.94&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>2</td>
<td>.31</td>
<td>.65&lt;sup&gt;a&lt;/sup&gt;</td>
<td>.87&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>3</td>
<td>.38</td>
<td>.70&lt;sup&gt;b&lt;/sup&gt;</td>
<td>.79&lt;sup&gt;b&lt;/sup&gt;</td>
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<tr>
<td>Average</td>
<td>.31</td>
<td>.70&lt;sup&gt;a&lt;/sup&gt;</td>
<td>.87&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a</sup> p < .01, with Condition 3 representing significantly higher DCPM.

<sup>b</sup> p < .05, with Condition 3 representing significantly higher DCPM.
Table 2

*Pre- and Post-Assessment Analyses on M-CBM Benchmark Probes*

<table>
<thead>
<tr>
<th>Participants</th>
<th>Pre-assessment</th>
<th>Post-assessment</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Addition</td>
<td>Subtraction</td>
</tr>
<tr>
<td>Student 1</td>
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<td>5</td>
</tr>
<tr>
<td>Student 2</td>
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<td>6</td>
</tr>
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</tr>
<tr>
<td>Student 7</td>
<td>19</td>
<td>6</td>
</tr>
<tr>
<td>Student 8</td>
<td>21</td>
<td>10</td>
</tr>
</tbody>
</table>

*Notes.* Mixed refers to a math assessment including both addition and subtraction problems.

*a* Improvements at post-test surpassed the expected growth of 4.2 DCPM, as reported by Fuchs et al. (1993).
Figure 1. Digit correct per minute (DCPM) median scores per group across conditions.