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Evaluating the Effectiveness of Progress Monitoring as a Second Grade Mathematics Intervention

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EVALUATING THE EFFECTIVENESS OF PROGRESS MONITORING AS A SECOND GRADE MATHEMATICS INTERVENTION

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AS A SECOND GRADE MATHEMATICS INTERVENTION

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An Abstract of the Dissertation Presented in Partial Fulfillment

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Progress monitoring has been shown to be effective for gauging student growth in the area of mathematics. Likewise, self-graphing has been shown to improve student achievement in education. The present study investigates the effectiveness of progress monitoring as an intervention with a self-graphing component for second-grade students in the area of mathematics. This research examines the impact of progress monitoring on increased math skills, accuracy, and generalization to universal screening assessments. While results were variable, students' accuracy improved upon implementation of progress monitoring. All-together, results suggest that progress monitoring with self-graphing can be an effective intervention.

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CHAPTER 1: INTRODUCTION AND LITERATURE REVIEW

The National Assessment of Educational Progress (NAEP) recently determined that 82% of U.S. fourth-grade students were performing below Proficient in mathematics (2011). According to the No Child Left Behind Act (NCLB, 2001), schools are mandated to the improve quality of instruction by requiring schools to implement scientifically-based research practices in the classroom. Due to the ongoing low rates of progress that U.S. students are showing on the NAEP, as well as the legal implications of the No Child Left Behind Act, it appears that U.S. schools are in desperate need of mathematics interventions to support all students' progress toward stronger math outcomes. In order to accomplish this, student progress must be reliably measured and best practices must be used.

Many years of empirical evidence have shown that curriculum-based measurement (CBM) reliably gauges student progress in the academic areas of math, reading and writing (Clark, 2009). The largest published set of CBM's is known as AIMSweb and is published by Pearson Education (NCS Pearson, 2008). Specifically for mathematics, AIMSweb has assessments known as Math Computation (M-COMP), Math Concepts and Applications (M-CAP) and the Test of Early Numeracy (TEN). Each of these assessments has items matched to the types of mathematical activities that students are likely to encounter at each grade level.

All of the AIMSweb math assessments are brief, ranging from two to eight minutes to administer. Scoring is also quick and made easier by scoring templates from AIMSweb. The newest of the AIMSweb math CBM is M-COMP. It was designed to be used for both universal screening and progress monitoring and the probes are used frequently to track student progress and monitor the effectiveness of interventions and school-wide programs. The M-COMP showed a median reliability of .88 for reliability in a field test sample (NCS Pearson, 2012). Therefore, it is an empirically supported method with extensive research evidence, particularly at the elementary level (Barge, 2012; Bushong, 2012; Kiburis, 2011). Progress monitoring is defined as the repeated measurement of academic performance to inform instruction of individual students in general and special education (National Center on Response to Intervention, 2012). It is typically used to (a) estimate rates of improvement, (b) identify students who are not demonstrating adequate progress and/or (c) compare the efficacy of different forms of instruction to design more effective, individualized instruction.

While progress monitoring has been used to look at a student's growth or improvement throughout the year, it has the potential for other uses. One strategy is using progress monitoring as an intervention to improve student outcomes. This process involves having students complete regularly scheduled progress measures and look at their scores before participating in a separate intervention, if needed. The idea is that by having students complete weekly CBM's and monitoring their own growth, they will benefit from this as an intervention alone; this would allow for more time to be spent in regular instruction and less time in multiple interventions or settings.

Studies specifically investigating the effects of progress monitoring as an intervention are uncommon. Schunk (1982) investigated the effects of progress monitoring on students' achievement and perceptions of self-efficacy in the context of mathematical competency development. The results of the study determined that monitoring student progress was extremely effective and that achievement improved for students who were previously struggling in mathematics. There has been similar research that validates the idea of progress monitoring as an intervention and outcomes have shown that students improved both math computation and math applications (Shapiro, Edwards & Zigmond, 2005). In the Shapiro et al. study, a total of 66% of students achieved the expected goals in computation and 37% in concepts/applications. The success rate for students after partaking in this intervention allowed them to engage in regular instruction, rather than be pulled out of a classroom for specialized instruction.

The most important aspect when implementing an intervention is that it must be individualized and geared toward a specific student; a blanket approach to intervention may not yield as valid and positive outcomes as individualized intervention. Fuchs, Mock, Morgan, and Young (2003) noted that there are two main ways to approach interventions for students who are struggling: standard protocols and problem solving methods. Standard protocols refer to using the same program with all students who exhibit a certain type of difficulty. Standard protocols have the benefit of being consistent for all students and require less teacher training. Nonetheless, not all students will respond to one or more standard protocols, therefore, some amount of problem solving will be needed as well. A problem-solving approach involves carefully reviewing a student's data and designing an intervention just for that student. According to Fuchs, Fuchs & Stecker (2010), problem solving may be seen as superior to the use of standard protocols for some students because it allows individualizing instruction. When needed, it is important to adapt interventions based on a student's idiosyncrasies and current data (Stecker & Fuchs, 2000). The concept of using progress monitoring as an intervention allows for this individualization, as well as being able to provide current and consistent data on a student's progress. In some cases, progress monitoring as intervention can be done with small groups of students, but at other times it may need to be individualized. There can be a standard set of procedures for each monitoring session, but student data will be unique. In cases when a student is significantly behind classroom peers, individualized monitoring sessions are often needed. Progress monitoring intervention has an added benefit of providing the opportunity to identify whether a student has a skills or performance deficit (VanDerHeyden & Witt, 2008). Skills deficits occur when a student does not have the specific acquired skills to perform a specific behavior. For example, if a student has not learned regrouping digits for carrying over amounts in addition, she will be unlikely to do addition problems that involve regrouping. But, if the student has the skill but does not perform in under certain conditions, then a performance deficit is observed. Performance deficits usually occur when a student has the needed skill but decides not to use the skill due to certain conditions. For example, a student who knows how to do addition with regrouping but does not complete such problems at all or accurately when seated next to her best friend, could have a performance deficit. This would be verified by seating the student elsewhere and then comparing math problem accuracy across the settings.

Skills and performance deficits are sometimes known as "can't" or "won't" conditions. Knowing whether a student can't or won't complete work is very helpful for teachers because then it's possible to provide targeted instruction based on the student's need. Progress monitoring intervention might offer additional information for teachers in relation to which students "can't" do certain work and which ones "won't." Specifically, after using progress monitoring as intervention, an analysis of the student's scores and errors on the weekly probes might shed light on what kinds of problems the student can do and what ones are frequently wrong or skipped. If a student completes some problems accurately, and there are no errors, then the data suggest that the student has the skills but is not performing them fast enough. In such cases, identifying a reinforcer for the student to earn as a result of faster accurate performance could be a helpful enhancement for the intervention.

Prior research has affirmed that using progress monitoring as intervention was associated with students obtaining significantly and substantially higher scores than students who do not experience the intervention (Fuchs, Fuchs, Compton, Bryant, Hamlett & Seethaler, 2007). Fuchs et al., 2007 showed that by the conclusion of the study, 76% of participants had obtained the maximum score during progress monitoring with an interventionist. Self-monitoring, or the act of recording one's own behavior, is one part of progress monitoring; the idea is that the act of recording might prompt self-reflection processes (Schmitz & Perels, 2011). The hypothesis behind progress monitoring is that when students can see their own progress and chart it themselves, they will be able to reflect and change their behaviors to increase their success. It has been shown that self-monitoring is an acceptable and cost-effective intervention that can be used in practical settings, such as schools (Fantuzzo and Polite, 1990). More specifically, students who record their progress on a graph yielded positive effects in mathematics and showed overall improvement in abilities (Shimabukuro, Prater, Jenkins, & Edelen-Smith, 1999).

The results of past research have demonstrated a functional relationship between self-graphing and the quantity/quality of work for students with learning disabilities (Stotz, Itoi, Konrad, & Alber-Morgan, 2007). The outcomes suggest that interventions with a graphing component may encourage students to evaluate their own progress, which in turn could improve their academics. Self-graphing also has logistical implications; if students fill in their own data, it saves time for the interventionist and helps students be in closer touch with their own skill performance (Brown-Chidsey & Steege, 2010). With a high level of treatment fidelity, procedures are easy to implement consistently and allow teachers to have time to provide quality feedback.

In addition, progress monitoring is student centered and allows for immediate feedback to the student (Luckner & Bowen, 2010). Feedback is the component of instruction that ensures that the child acquires the target skill by reinforcing a correct response and nothing else (Burns, Riley-Tillman & VanDerHeyden, 2012). Research suggests that when students receive immediate and prompt feedback during progress monitoring intervention, they will be able to learn in an efficient and effective way. Based on the body of existing research, using progress monitoring as an intervention, along with a self-graphing component, shows some promise as an effective, valid approach to improving students' math skills. However, experimental research in this area is limited and there is a need for more research that identifies specific progress monitoring procedures associated with student gains. The purpose of this study is to determine whether weekly progress monitoring will enhance math performance.

Research Question and Hypotheses

Based on existing research, self-graphing and using progress monitoring as an intervention, show some promise as an effective and valid approach to improving students' mathematic skills. Research on progress monitoring as an intervention is very limited, which is another reason why the current study is an important addition to the field. The purpose of this study was to determine if students can benefit from progress monitoring as an intervention to improve math skills. Specifically, this study examined the effects of progress monitoring and self-graphing, with and without an instructional component, on total number of digits correct on grade-level CBM probes. The research hypothesis was that weekly progress monitoring as an intervention would enhance math performance among students at risk for math difficulties.

CHAPTER 2: METHOD

Design

The research design used in this study was a multiple baseline across subjects design (MBD). In the multiple baseline across subjects design, one target behavior is selected for two or more subjects in the same setting (Cooper, Heron & Heward, 2007). After steady responding has been achieved under baseline conditions, the independent variable is applied to one of the subjects while baseline conditions remain in effect for the other subjects. When stable responding has been attained for the first subject, the independent variable is applied to another subject and so on. The most important advantage of this design is that it does not require withdrawing a seemingly effective treatment to demonstrate experimental control (Cooper, et al., 2007). It is also well matched to research on academic behaviors such as math and reading that are typically immune to regression in withdrawal conditions. Additionally, this design is practical in an applied setting and is useful in assessing the occurrence of generalization of behavior change. For the current study, all participants demonstrated stable baseline data prior to beginning the intervention. Once progress monitoring had been implemented, enrollment of additional students was based on evidence of 3 or more stable data points in the current students' data.

This specific MBD design had two conditions for all students and a third condition for any student who did not make adequate progress. The first condition was the baseline condition in which a student completed a mathematics computation probe and received no feedback. The second condition was the intervention (progress monitoring) condition in which the student received scripted feedback after completing a probe. The third condition was the progress monitoring and instruction condition in which students received scripted feedback and instruction on key skills; this condition was only provided to students who did not make adequate progress in the feedback condition.

Participants

The sample included a purposeful selection of students from differing backgrounds, gender, and abilities. The participants included four second-grade students identified as falling between the 25th and 40th percentile on the Winter AIMSweb mathematics computation (M-COMP) Benchmark. This range of scores controlled for skills and allowed for a valid sample. There were two female participants and two male participants. None of the participants were receiving special education services as a result of an Individualized Education Program (IEP). Data collection began after the researcher received approval from the university's Institutional Review Board and parent consent, as well as student assent, was obtained. The second grade teacher provided the researcher with a list of nine students who met the criteria; a letter and parent consent form were sent to the parents of all students. The first two boys and first two girls to return the parent consent were chosen for the study. These students remained in the same general education math class to maintain internal validity and increase the likelihood that no extraneous variables accounted for their intervention performance.

Baseline data indicated that one student was performing at the 30th percentile in Math Computation, one student was performing at the 28th percentile, and the remaining two students were performing at the 25th percentile. Given the relative similarity of their scores, the four participants were randomly assigned to a specific order to receive the intervention. Nonetheless, each student's entry into the study was also dependent on demonstration of stable baseline scores. According to AIMSweb normative data, second grade students should be producing an average score of 16 for the Winter M-COMP Benchmark.

Setting

The study took place in a suburban public elementary school in the Northeast. Data collection and intervention took place two days a week during the time allotted for class instruction in mathematics. The student and the researcher met in a quiet room away from other classmates or distractions to engage in the intervention. The second condition, which was intervention and scripted feedback, took no more than 10 minutes, which allowed the student to re-enter the classroom and engage in whole-class instruction. The third condition, which was explicitly teaching key skills, took up to fifteen minutes depending on the probe answers.

Materials

Student performance on grade level Mathematics Computation (M-COMP) AIMSweb Benchmark scores was used to determine eligibility for the study. M-COMP is a brief, standardized test of math operations that are part of the typical curriculum. M-COMP includes a recently revised collection of probes that samples math problems consistent with instructional goals at each grade level from first through eighth grades (Pearson, 2008). The participating school used M-COMP as part of universal screening procedures; the 2013 Winter Benchmark scores were provided to the researcher by the school. A different AIMSweb math curriculum-based measure (M-CBM) was used for the progress monitoring tool, and M-COMP was used as the dependent variable. The research team used a script to provide students feedback during the second and third condition (see Appendices). In addition, graph paper was used so that students could self-graph their results.

Procedure

The following experimental conditions were implemented: baseline, progress monitoring (PM) , progress monitoring + direct instruction (PM+DI), and debriefing (follow-up questionnaire). Once the first student demonstrated a stable baseline, the PM intervention was started. Similarly, once the first student's data showed a response to the intervention and maintained stability (3-5 data points), the next student began to receive the intervention while the remaining students continued in the baseline condition. This process continued until each student had received intervention. All four students engaged in the debriefing condition at the conclusion of the study.

Baseline: Winter Benchmark. All students in the second grade were given the AIMSweb M-COMP Benchmark as part of universal screening. As described, the research team used the Winter Benchmark data to select students in the second-grade instructional team who performed between the 25^{th} – 40^{th} percentile. Four students were selected to receive the intervention. After parent permission and student assent were obtained, the selected students then completed additional M-COMP protocols to develop a true baseline. This allowed for verification of the students' pre-intervention math skills. In order to prevent carryover effects, a member of the research team (i.e., a trained volunteer graduate student in a School Psychology doctoral program) administered and scored some of the M-COMP baseline assessments. Students who were awaiting intervention continued completing M-COMP probes once every other day until their data were stable and it was their turn to receive the progress monitoring intervention.

Intervention 1: Progress Monitoring (PM). The research team served as the interventionists for the study. In the intervention condition, the student met with a member of the research team on the first school day (Monday) and last school day of each week (Friday) in a quiet area of the school during mathematics instruction. The student was pulled at the beginning of mathematics class and only missed five to ten minutes of the class. The student was given a CBM math computation fluency probe that was timed for 2 minutes; these probes were different from the M-COMP ones used for universal screening. No M-COMP probes were repeated during either intervention phase. After the 2 minute -COMP, the student and researcher scored the probe together. In order to ensure validity and consistency of feedback, the researcher followed a script that was adapted from the Peer Assisted Learning Strategies (PALS) manual (Fuchs, Fuchs, Yazdian, & Powell, 2002). PALS is peer tutoring instructional intervention (Fuchs, et al., 2002). The student received one point for every correct digit. The total number of correct digits was written on the top of the probe and the student graphed his or her progress on the provided graph paper in a bar graph format. Following each intervention session, the student returned to class.

In order to assess reliability and validity of data, interobserver agreement (IOA) data were collected. Treatment integrity was evaluated by having a volunteer graduate student observe 20% of the baseline and progress monitoring sessions and complete a 5-item checklist to verify that the interventionist was accurate in the execution of the baseline and intervention probes (see Appendices). In order to assess assessment accuracy during intervention implementation, 20% of the intervention probes were scored by both the interventionist and the volunteer graduate student. IOA was calculated by dividing the number of agreements by the sum of agreements plus disagreements. The resulting percentage indicated the level of IOA.

Intervention 2: Progress Monitoring + Direct Instruction (PM+DI). In the third condition, the student met with the researcher for a more targeted intervention. In the present study, this condition only occurred for one student who did not make adequate progress in the second condition (progress monitoring). The student met with a member of the research team on the first school day (Monday) and last school day of each week (Friday) in a quiet area of the school during mathematics instruction. The student was given a CBM math computation fluency probe that was timed for 2 minutes. When the allotted time concluded, the student and interventionist scored the probe together. The interventionist was trained to explicitly teach key skills depending on the items that were answered incorrectly. The interventionist provided direct instruction to the student based on the observed errors and the student's target math learning area. The student received one point for every correct digit. The total number of correct digits was written on the top of the probe and the student graphed his or her progress on the provided graph paper in a bar graph format. Following each intervention session, the student returned to class.

Debriefing. After the research study concluded and each student had shown adequate progress, a member of the research team met with each student who engaged in progress monitoring and completed a short, follow up questionnaire. This questionnaire included questions to gauge how the student felt about the intervention(s) and understand how the student felt about the process. The questions were read out loud to the students. This aspect of the study added a qualitative component that allowed the researcher to reflect on the current study.

Data Analysis Methods

Once every student completed the intervention, the researcher graphed the baseline and intervention results to show the results of the study for each condition. In order to consider the data from multiple perspectives, three graphs were created: (a) raw scores on PM problems, (b) percentage of problems correct on both universal screening and PM assessments, and (c) scores on the universal screening probes as well as the short and long-term goals for these measures. On each graph, the data from baseline phase and the intervention phase(s) were graphed and interpreted using visual inspection of the data. The percentage of non-overlapping data points was also calculated by identifying the highest data point in baseline and determining the percentage of data points during intervention(s) that exceeded this level. The effect size was determined using the percentage of non-overlapping data points for each student. With this method, the higher the percentage is, the more effective the treatment has been (Scruggs & Mastropieri, 1998). Research suggests that percentages above 90 represent very effective treatments, scores from 70 to 90 represent effective treatments, scores from 50 to 70 were questionable, and scores below 50 were ineffective.

CHAPTER 3: RESULTS

The results of the current study were expected to reveal that all students would show improvements in their scores, as compared to the baseline data. In addition, it was expected that students who did not show adequate progress during progress monitoring would show improvements during the third condition of progress monitoring plus instruction. It was anticipated that while all students would make improvements in math performance, there would be variability among these gains due to personal characteristics and maturation. The three types of data were organized into time series graphs. These included the raw scores on probes in baseline and during intervention (Figure 1), percentages of accuracy in baseline and during intervention (Figure 2), and pre- and post-intervention AIMSweb benchmark scores. (Figure 3). The following results include consideration of interobserver agreement and treatment integrity data.

Impact on Raw Scores

The raw score results of the students' baseline and intervention are displayed in Figure 1. The raw scores reflect the students' math fluency because the assessments were timed. All four students who participated in the study had somewhat variable raw scores, both during baseline and during intervention. During baseline, Student A's raw scores showed a descending trend, ranging from 12 to 23 with a mean of 17. During intervention, raw scores ascended and ranged from 10 to 34 with a mean of 25. When determining effect size, Student A had 64% non-overlapping data points. Student A did not continue receiving intervention throughout the study; she was withdrawn as a participant due to the fact that she was referred to Special Education. As a result of the special education referral she began receiving math instruction as part of an

Figure 1. Raw Scores on Probes in Baseline and During Intervention Conditions.

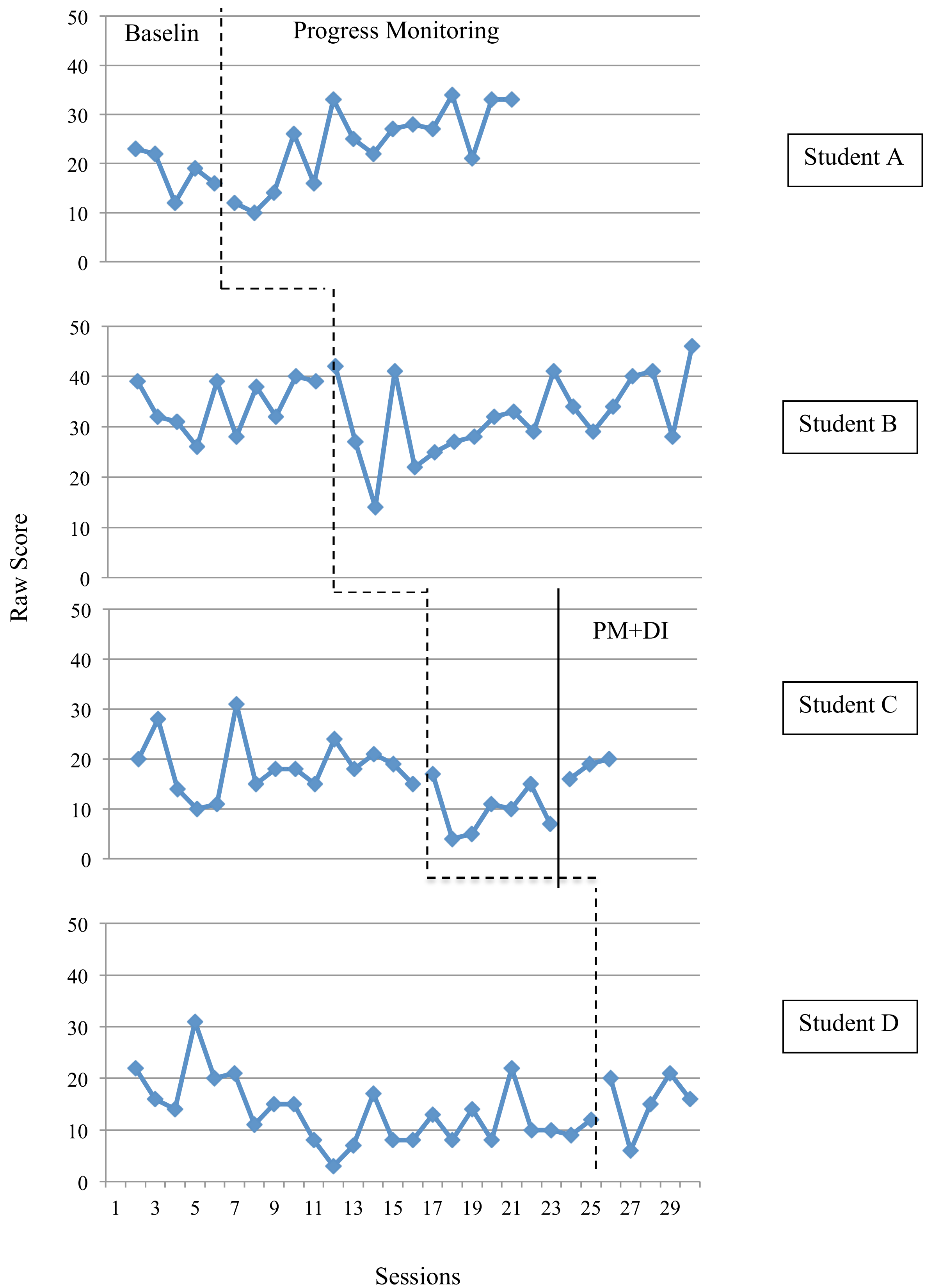
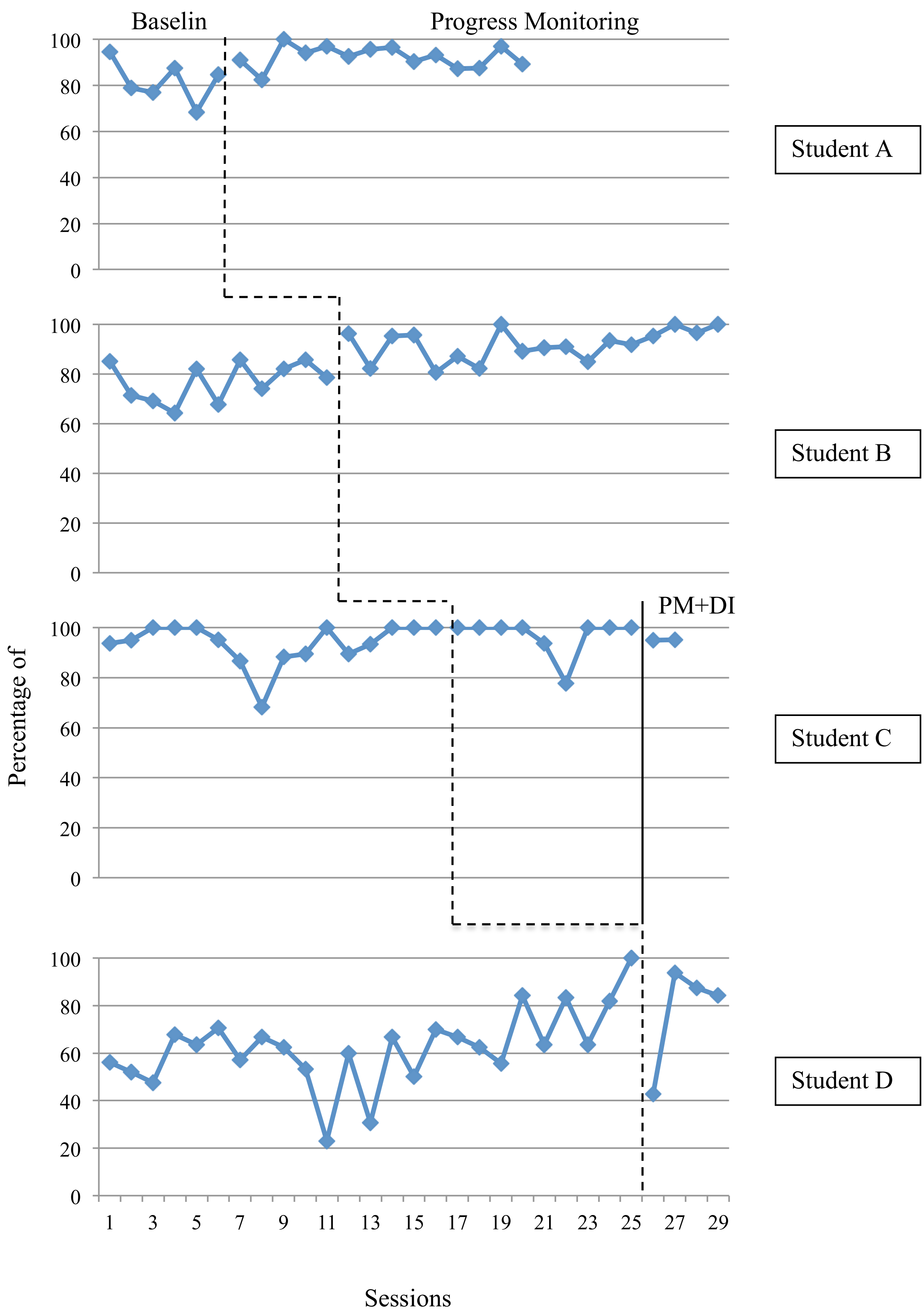


Figure 2. Percentage of Accuracy in Baseline and During Intervention Conditions.



education program (IEP); due to this confound, she was withdrawn from the study.

Student B's raw score baseline data remained relatively stable, ranging from 26 to 42 with a mean of 35. During the intervention phase, the raw scores revealed an ascending trend and ranged from 14 to 46 with a mean of 32. Student B's data showed 6% non-overlapping data points.

During baseline for Student C, scores ranged from 10 to 31 with a mean of 18 and showed a descending trend. During the PM intervention phase, the raw scores ranged from 4 to 16 with a mean of 10. Due to the fact that the student was not making adequate progress, PM+DI was implemented for the student. In this phase when the student made a mistake during the 2 minute PM assessment, he was cued for the correct answer. During this condition, raw scores ranged from 19 to 20 with a mean of 19.5 and revealed an ascending trend. The percentage of non-overlapping data, in both the PM and PM+DI conditions was 0%. Nonetheless, Student C's scores from the PM+DI condition showed an improving trend.

Student D's scores showed a descending trend during baseline and had scores that ranged from 3 to 31 with a mean of 14. After the intervention was implemented, Student D's scores remained relatively stable ranging from 6 to 21 with a mean of 15. When determining effect size, Student D had 0% non-overlapping data points.

Effects of Progress Monitoring on Percentage of Accuracy

To further determine the effects of the progress monitoring, the raw data scores were converted to percentages of accuracy (Figure 2). Percentage of accuracy was determined by taking the number of items correct and dividing it by the number of items attempted. Table 1 shows each student's mean percentage of accuracy during baseline, during intervention(s) and provides information about whether the mean percentage of accuracy increased or decreased.

Table 1

Pre- and Post-Intervention Mean Percentage of Accuracy

	Baseline Mean Percentage of Accuracy	**Intervention 1 Mean Percentage of Accuracy**	**Intervention 2 Mean Percentage of Accuracy**	**Increase or Decrease from Pre- to Post-Intervention**
Student A	82%	92%	N/A	Increased
Student B	77%	92%	N/A	Increased
Student C	94%	97%	95%	Increased
Student D	62%	77%	N/A	Increased

Student A produced scores in baseline that revealed decreasing accuracy, ranging from 68% to 94%. The mean score was determined to be 82%. During intervention, Student A's accuracy showed a relatively stable trend with scores ranging from 82% to 100%, and a mean of 92%. In relation to accuracy, Student A had 38% non-overlapping data points.

During baseline, Student B's scores revealed increasing accuracy, ranging from 64% to 86% and a mean of 77% accuracy. When the intervention was implemented, Student B's accuracy increased, and ranged from 81% to 100% with a mean accuracy percentage of 92%. Student B's accuracy showed 78% of non-overlapping data points.

Student C's accuracy during baseline showed a relatively stable trend, with accuracy ranging from 68% to 100% and a mean score of 94%. During the first intervention phase, Student C's accuracy showed a stable trend, ranging from 77% to 100% and a mean of 97%. When the progress monitoring plus direct instruction intervention was implemented, Student C's accuracy showed a stable trend resulting in 95% mean accuracy percentage during this condition. The percentage of non-overlapping data points for both interventions was 64%.

During baseline, Student D's accuracy showed an ascending trend despite considerable variability, ranging from 23% to 100% and a mean score of 62%. When intervention was implemented, Student D's accuracy indicated another ascending trend with scores ranging from 43% to 94% with a mean accuracy percentage of 77%. Student D's accuracy showed 0% of non-overlapping data points.

Impact on Universal Screening Scores

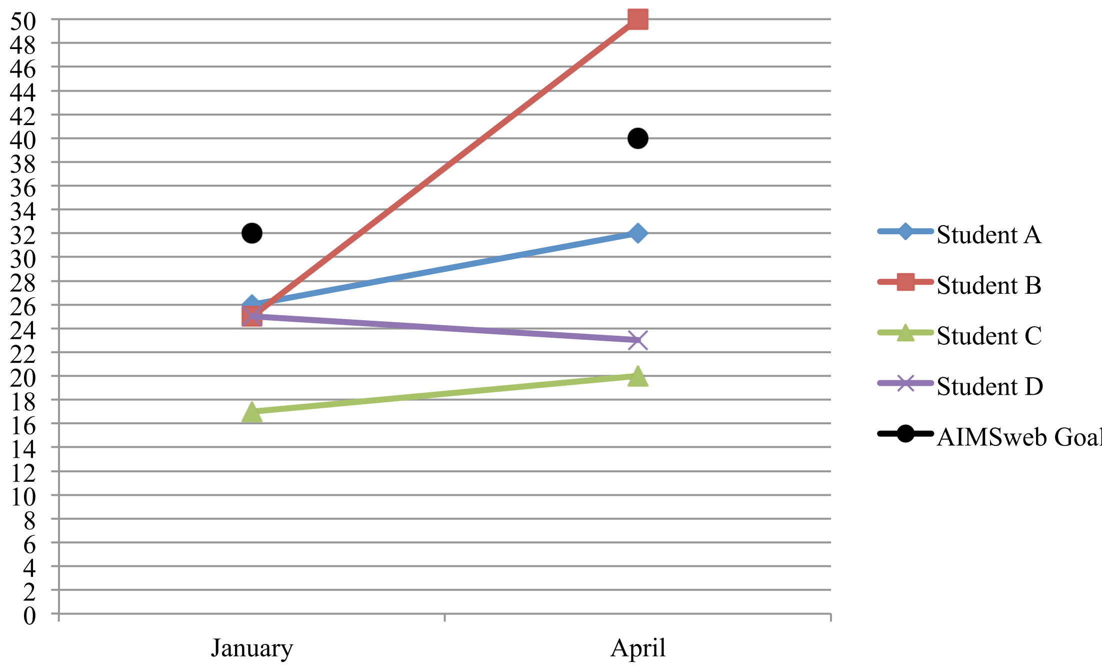
The pre-test and post-test results on the M-COMP benchmark assessments are presented in Table 2 and also in Figure 3. For the AIMSweb Winter Benchmark, the 50th percentile score was 32 . For the Spring Benchmark, the 50th percentile score was 40; the goal for this study was for students to meet or exceed scores at the 50th percentile. In

Table 2

Pre- and Post-Intervention Benchmark Scores (Percentiles) and Rates of Improvement (ROI)

	AIMSweb Winter Score and (% Rank)	**AIMSweb Spring Score and (% Rank)**	**Obtained Rate of Improvement (ROI) per week**	**Expected Rate of Improvement (ROI) per week**
Student A	26 (28)	32 (27)	.40	
Student B	25 (30)	50 (95)	1.67	.67
Student C	17 (25)	20 (8)	.20	
Student D	25 (25)	23 (11)	-0.13	

Figure 3. Pre- and Post-Intervention AIMSweb Benchmark Scores.



addition, the Rate of Improvement (ROI) was also calculated for each student and was compared to the AIMsweb second-grade M-COMP ROI of .67, which is based on a national normative sample.

Students A, B and C received intervention prior to the Spring benchmark assessment. Student D was the only student who did not receive intervention prior to benchmark; this was due to the fact that it took more time to get stable scores from Student C and MBD requires stable data before a new student can begin receiving intervention.

A score of 40 on the Spring benchmark assessment would put a student in the 50th percentile. Students A, B, and C all made improvements in their M-COMP scores, however, only Student B scored above the 50th percentile; indeed, she received a perfect score on her Spring benchmark (95th percentile). Students A (32) and C (20) made improvements that were not strong enough to meet the Spring benchmark goal. Student D did not make gains toward the Spring benchmark, but started the intervention after those data were collected.

Interobserver Agreement

The primary researcher served as an observer during sessions when the members of the research team provided the intervention. All members of the research team received training in how to score the probes and reached 100% agreement with the trainer on two consecutive trials. In order to assess interobeserver agreement (IOA), 30% of the intervention probes (i.e., 7 sessions) were scored by both the interventionist and primary researcher. The two scorers' results were compared and interobserver agreement was calculated using item-by-item analysis. Specifically, the scorers' marks (correct or incorrect) were compared, and the number of agreements was divided by the total number of agreements plus disagreements. This number was then multiplied by 100 to convert it to a percentage. IOA agreement ranged from 99% to 100% with a mean of 100%.

Treatment Integrity

Treatment integrity was assessed for 9 of the 23 sessions (39%) by the members of the research team. The observer used a 10-item checklist to verify that the interventionist was accurate in the implementation of the intervention and maintained integrity during treatment. Treatment integrity was determined to be 100% for all sessions.

Social Validity

At the end of the study, each student debriefed with the interventionist and was asked 5 questions, to which the student could respond with "Yes" or "No"; the students were also asked to explain why they chose their answer. A "0" indicated the lowest acceptability ("No") and 1 indicated the highest acceptability ("Yes"). The exception to this was the fourth question, which asked students to describe what they would have changed in the study.

Table 3 shows the results of the social validity questionnaire. All four students strongly agreed (i.e., "1" rating) that the graphs were helpful and that they enjoyed the graphing aspect of the study. The students also indicated that they believed that their work with the interventionist helped them become better at math in their classes. There were a variety of comments in addition to the questionnaire answers. On the first question, three out of the four students responded that the work with the interventionist

Table 3

Questionnaire Results.

Questionnaire item	Mean	Range
Did you like working with the Math Team?	.75	0-1
Do you think working with the Math Team has helped you be better at math?	1	1
Did you like the graphing part of our work together?	1	1
If you could change anything about your math work, what would it be?	N/A	N/A
Is there anything else about our working together that you want to tell me?	0	0

was “fun.” For the second question, one student commented that the work with the interventionist “helped during Fast Math and I am getting better every time we meet!”

CHAPTER 4: DISCUSSION

The purpose of this study was to determine if progress monitoring was effective as an intervention to improve math skills for second grade students. While there is little prior research to determine if students can benefit from progress monitoring as an intervention, Schunk (1982) found that progress monitoring was effective for student achievement in mathematics. Similar research has shown that progress monitoring produces improvements in both math computation and math application (Shapiro, Edwards & Zigmond, 2005).

When determining if progress monitoring was an effective intervention in the current study, raw scores from M-COMP baseline probes and CBM progress monitoring probes were examined. Overall, results were variable for improvement in raw scores during the progress monitoring condition. Two students (Students A and D) showed increases in mean raw scores, while the other students (Students B and C) showed a decrease in mean raw scores. Student C was involved in the third condition (PM+DI) due to inadequate progress and showed an improved trend in fluency (e.g., raw scores) once this additional condition was implemented.

The raw score data revealed important information regarding skills versus performance deficits (i.e., “can’t do” versus “won’t do”); for example Student D skipped questions on the CBM probes and answered only questions that he was able to correctly solve. This appeared to be addition problems with a “zero” digit, as well as simple one-digit addition problems. Student D often skipped more difficult problems (i.e., two- or three-digit addition and subtraction problems). When prompted to complete the problems in order, most of the more difficult problems resulted in an incorrect answer. Such a pattern is consistent with a student who has skill deficits in certain areas. Reviewing the students' data allowed the interventionist to determine which types of problems the student could not do and what interventions/instruction might be helpful.

The percentage of accuracy on all probes was also calculated to identify whether progress monitoring was effective in improving the students' math accuracy. Compared to the raw scores, the accuracy data indicated that the progress monitoring intervention yielded improved accuracy among all the students. The results indicated that each participant's percentage of correct answers increased during intervention. Interestingly, Student C's accuracy percentage during the third condition (PM+DI) decreased slightly from the PM condition. This effect makes sense given that this student was already very accurate. Student C was very accurate in all conditions (above 90%) but did not demonstrate overall progress during the first phase of intervention. The collected data suggest that the lack of progress was due to the fact that he worked accurately, but slowly, when completing the probes; therefore, the time limit impacted his scores negatively. The research design used in this study was based on the premise that students who failed to make fluency gains would need more instruction to improve accuracy; thus, the interventionist implemented the PM+DI condition. But, for Student C, this addition to the intervention did not appear to work because his accuracy was already strong. Instead, he needed an intervention focused on faster completion of math problems, i.e., fluency.

The current findings suggest that students with both skills and performance deficits might benefit from a progress monitoring intervention. This is consistent with prior research that suggests having students track their progress improves overall performance (VanDerHeyden & Witt, 2008). All of the students in this study improved their math accuracy even though only one student (A) improved math fluency. The findings suggest that the feedback provided in the form of a visual graph showing student progress helped the students to be more accurate, even if not faster. This conclusion is confirmed by the finding that Student C did not make any more improvements when provided with direct instruction as part of the second intervention phase. This student's problem appears to have been fluency, not accuracy. It is notable that three of the students made accuracy gains from a very brief intervention in which the only corrective feedback was scoring and graphing their scores. Similar with prior research on the benefits of self-graphing, this study's findings appear to indicate that feedback provided to each individual student through counting and recording performance on the 2 minute probes is an effective form of intervention.

The AIMSweb benchmark scores were used to select students for the current study, but were also used as a measure of generalization. One hypothesis of the study was that the progress monitoring intervention would generalize to the students' spring benchmark scores. Therefore, the goal was that each participant would meet or exceed the 50^{th} percentile on the Spring benchmark assessment. At the Winter benchmark, none of the participants met or exceeded the 50^{th} percentile score of 32. After the intervention was implemented for 3 out of the 4 participants, the Spring benchmark was administered and one of the participants met or exceeded the 50^{th} percentile score of 40. Despite only one student meeting the spring benchmark, two others did make notable gains toward the benchmark and the other student who did not show such a gain had not yet started the intervention.

When raw scores, percentage of accuracy, and universal screening scores are looked at in conjunction with one another, the combination suggests that progress monitoring could be a useful intervention for students struggling in mathematics. Three of the four students in this study made improvements in their math skills from the winter to spring benchmarks, with the most notable gains in accuracy. Student C showed less aggressive growth and he was provided with additional instruction in addition to progress monitoring. This enriched condition did not lead to improvements in performance beyond those seen with progress monitoring alone, most likely because this student's math difficulties were rooted in fluency, and not accuracy.

The progress monitoring intervention was generally appealing and welcome among the participants. As noted in the questionnaire results, all four participants agreed that the progress monitoring intervention helped them become better in math and they felt that the self-graphing component was advantageous. The results of the current study suggest that such an intervention is seen as positive by second grade students for developing better mathematics skills.

Limitations and Future Research

The conclusions that are presented in this study should be interpreted with caution, due to the fact that a multiple baseline across subjects design was used and there are limitations that exist with this type of design. The increase in math ability may not be functionally independent from other variables such as math instruction during class, maturation, etc. For this reason it cannot be assumed that the change in skills was due only to the intervention. Another limitation of this design is that the intervention was not withdrawn to examine its effectiveness. Typically, math skills such as those included in this study do not regress when instruction is withdrawn. It is unlikely that the students would have shown a significant decrease in skills if a withdrawal condition were applied, but it cannot be known.

Additionally, the use of the AIMSweb probes may have been a limitation of the study. These assessments sample a very small set of students' math skills and may not have reflected their true gains. In addition, AIMSweb protocols do not allow for demonstration of which algorithm the student used to solve each problem. As a result the M-COMP assessments may not have been sensitive to true student growth. There were also confounds that occurred during the study that limit the interpretation of results and generalizability. Student A was not able to complete the study due to the fact that she began receiving Special Education services in mathematics. While her results appeared promising, these cannot be interpreted as complete. Another limitation is that Student D was not able to participate in the intervention condition for very long. Due to the instability of Student C's scores and the fact that Student D had to wait for scores to become more stable before beginning intervention, he was not able to receive as much progress monitoring as the other students. The limited data sets from certain students may have created incomplete indications of the true effects of the intervention.

The current results have implications for future research in progress monitoring as an effective intervention. First, it would be beneficial to examine progress monitoring across all abilities and disabilities. The current study chose to look at students who were struggling with math and were not receiving Special Education services. In order to increase social validity and generalizability, future research should include participants of a more diverse range of math abilities. This would allow teachers to determine if progress monitoring could be used class-wide as an effective intervention. Second, future research could add a reinforcement condition to learn whether math fluency can be enhanced through motivation. Last, technology should be incorporated into the intervention. Due to the fact that students have ever-growing access to computers and iPads in school, an intervention that utilizes such technology to graph their results might be easier for students to use, and lead to additional increases in student motivation.

Implications for Practice

Progress monitoring as an intervention can be easily implemented in day-to-day education practices. A benefit of this intervention is that it is quick; in the current study, time spent on progress monitoring probes ranged from 5-10 minutes per session, depending on if direct instruction was being provided. The intervention can be implemented quickly at the beginning of the math class with an individual student, small group or class-wide. Progress monitoring with a self-graphing component is also very cost effective; the only materials needed are graph paper and CBM probes, which can be created by teachers or found online for free.

Also, a progress monitoring intervention can be individually tailored to individual students (e.g., each student has problems specific to his or her current skills) and still be administered class-wide so that a teacher can gauge all students' progress. This allows for the teacher to determine where student strengths and weaknesses lie, and if there are areas that are difficult for more than one student (i.e., "can't do"). Likewise, the teacher can compare the efficiency of instruction and can quickly identify whether adequate progress is being made.

CHAPTER 5: SUMMARY

A small number of studies have shown the effectiveness of progress monitoring and self-graphing as effective interventions for improving student skills. The present study examined if students would benefit from a combination of these methods when progress monitoring of math skills was combined with a self-graphing component. The students in this study showed some improvements in math skills, specifically in accuracy. Nonetheless, only one student met the goal of meeting and/or exceeding the 50th percentile on the AIMSweb Spring benchmark assessment. Prior research indicated that self-graphing was effective for improvement in academics; this study investigated the impact of self-graphing on improvement in math abilities and demonstrated mixed results. Still, all participants endorsed that the self-graphing component was helpful and felt that they were doing better in math as a result of progress monitoring and self-graphing. The findings in this study suggest that progress monitoring, used as a weekly intervention with an embedded self-graphing component, might be effective for students struggling in mathematics.

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Appendix A: Treatment Integrity Checklist

M-COMP Treatment Integrity Checklist

Observer's Initials: _________ Date: _____________

Step 1 = The child is set up in a quiet space and has 2 sharpened pencils with erasers and no calculator _________(Observer's Initials)

Step 2 = The researcher read the administration directions exactly as they are printed in the AIMSweb manual _________(Observer's Initials)

Step 3 = The researcher began timing after telling the student to "Begin" _________(Observer's Initials)

Step 4 = The researcher told the student to "Stop, put your pencil down" when the allotted time ran out _________(Observer's Initials)

Step 5 = The researcher went through the probe with the student and corrected each problem according to the scoring rules in the AIMSweb manual _________(Observer's Initials)

Step 6 = The researcher totaled up the number of correct digits and wrote it on the top of the page _________(Observer's Initials)

Step 7 = The researcher gave the student a piece of graph paper, a ruler and colored pencils after the probe had been corrected _________(Observer's Initials)

Step 8 = The student graphed their progress by creating a bar graph using their number of correct digits for that probe _________(Observer's Initials)

Step 9 = The researcher and the student reviewed the student's progress together, looking at the bar graph for reference _________(Observer's Initials)

Step 10 = The researcher will add the student's probe and graph to a folder designed only for that student's materials _________(Observer's Initials)

Appendix B: Intervention 1 (Progress Monitoring) Script

UNIVERSITY OF SOUTHERN MAINE

Script1

School Psychology Program

Intervention 1 Script

1.) Say: "Let's go through the worksheet together."

2.) Point at the first problem on the worksheet. Say: "We're going to look at each digit in the problem. If you wrote any digit correctly, I'll draw a circle around it. If you wrote an incorrect digit, I'll draw a triangle around it. Do you have any questions?"

3.) Answer any questions that the student may have.

4.) If the student does not have any questions, go through each problem and circle the correct digits. If you come to a digit that is incorrect, simply put a triangle around the digit – **DO NOT PROVIDE THE STUDENT WITH THE CORRECT ANSWER OR ANY INSTRUCTION!**

5.) If a student asks about an incorrect digit (i.e. "What's the answer supposed to be?"), respond that you will go over the correct digits with them at a different time.

6.) Once all the correct digits have been circled, count aloud the number of digits correct.

7.) Write the number of correct digits at the top of the worksheet and circle it.

8.) Take out the student's Progress Graph and have them graph their number of correct digits for that day.

9.) Reinforce the student for doing a good job (i.e. "Thanks for working with me today! You did a great job!") and have them return to class.

10.) Put the CBM worksheet on top of the other probes on the right hand side of the folder. Put the student's Progress Graph on the left side of the folder.

Appendix C: Intervention 2 (Progress Monitoring + Direct Instruction) Script

UNIVERSITY OF SOUTHERN MAINE

Script2

School Psychology Program

Intervention 2 Script

1.) Say: "Let's go through the worksheet together."

2.) Point at the first problem on the worksheet. Say: "We're going to look at each digit in the problem. If you wrote any digit correctly, I'll draw a circle around it. If you wrote an incorrect digit, I'll draw a triangle around it. Do you have any questions?"

3.) Answer any questions that the student may have.

4.) If the student does not have any questions, go through each problem and circle the correct digits. If you come to a digit that is incorrect, tell the student that s/he made an error (i.e. say: "That digit is incorrect.", "That's not quite right, but you're close.", "Oops. You made an error.", etc.).

5.) Ask the student to fix the error (i.e. say: "Can you fix your answer?", "Try this one again.", "Can you correct your error?", etc.).

6.) Allow the student to attempt to correct the digit. If the student needs help, provide support and prompts. You can help the student any way that you think s/he will learn best. Just use your own words.

7.) You and the student can also go back through the entire problem if they need to.

8.) After the digit is correct, draw a triangle around it. Be sure to <u>wait</u> until the digit has been corrected before drawing a triangle around it.

9.) Once all the problems have been scored, count aloud the number of digits correct.

10.) Write the number of correct digits at the top of the worksheet and circle it.

11.) Take out the student's Progress Graph and have them graph their number of correct digits for that day.

12.) Reinforce the student for doing a good job (i.e. "Thanks for working with me today! You did a great job!") and have them return to class.

13.) Put the CBM worksheet on top of the other probes on the right hand side of the folder. Put the student's Progress Graph on the left side of the folder.

Appendix D: Follow-Up Questionnaire

UNIVERSITY OF SOUTHERN MAINE

Form PQ1

School Psychology Program

Student Follow-Up Questionnaire

Student ID: ______________________________ Date: ________________________

1. Did you like working with the Math Team?

___ Yes
___ No

Why or why not?

____
____
____
____
____

2. Do you think working with the Math Team has helped you be better at math?

___ Yes
___ No

Why or why not?

____
____
____
____
____

(Continued on next page)

3. Did you like the graphing part of our work together?

___ Yes
___ No

Why or why not?

4. If you could change anything about your math work, what would it be?

5. Is there anything else about our working together that you want to tell me?

___ Yes
___ No

BIOGRAPHY OF THE AUTHOR

Courtney L. Bartlett was born in Albany, New York, and received her Advanced Regents diploma from Colonie Central High School in 2006. She earned a B.A. in Psychology from Siena College in Loudonville, New York in 2010. Ms. Bartlett moved to Maine in August 2010 and enrolled in the University of Southern Maine graduate program in School Psychology.

While enrolled in classes, Ms. Bartlett was a Graduate Assistant for the Center Education Policy, Applied Research, and Evaluation (2010-2012), Dr. Julie Alexandrin (2011-2013) and the School Psychology Program (2012-2013). Ms. Bartlett served as Psy.D. Student Representative from 2010-2012. Ms. Bartlett was also elected as the 2011-2012 Maine Student Affiliates of School Psychology (MaineSASP) president. In the fall of 2012, Ms. Bartlett was chosen as a Teaching Assistant for the *Assessment of Academic Achievement* course at the University of Southern Maine.

In 2013, she earned her M.S. in Educational Psychology from the University of Southern Maine. Currently, Ms. Bartlett is finishing the pre-doctoral internship requirements in the RSU14 Windham Raymond School District. She is a candidate for the Psy.D. degree in School Psychology from the University of Southern Maine in August, 2014.