EXPLORING A COMBINED INSTRUCTIONAL AND SELF-REGULATORY INTERVENTION FOR MATH ANXIETY

by

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Exploring a combined instructional and self-regulatory intervention for math anxiety submitted by Nathalie Sagar in partial fulfillment of the requirements for the degree of Master of Arts in School Psychology.

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Abstract

Math is a fundamental component of children’s education, as well as an essential skill for future learning. Although math is a fundamental component of a child’s education, many children have difficulty with math due to symptoms of math anxiety. Despite the gravity and pervasiveness of math anxiety, there is currently no consensus on an intervention to mitigate its detrimental effects. To date, few studies have utilized a combined instructional and self-regulation intervention to decrease math anxiety. In the present study, I investigated a pilot series of lessons incorporating both self-regulated learning and schema-based math instruction. Using the lessons successfully increased math word problem solving and somewhat decreased feeling so of math anxiety amongst four students in grades one and two within the context of a multiple probe across students design. Further, the lessons slightly increase student motivation and positive attitudes towards math. Future research should continue to investigate components of self-regulation as an important component to math instruction and should continue to try to increase the ecological validity of measures of math anxiety particularly within children.
Lay Summary

Math anxiety is a common negative emotional reaction someone might have when asked to complete a math task. Some may experience math anxiety to a greater degree when asked to complete a math word problem as they often involve multiple steps. Self-regulation is one’s ability to control their own thoughts, feelings and actions. It has been suggested that having students engage in self-regulation may be useful to increase math performance and decrease math anxiety. This study combined proven math instruction strategies and self-regulated learning. We found that this intervention helped students to increase their math performance on math word problems. There was evidence that the intervention helped decrease math anxiety in two of the students, but it was not generally helpful for the other two. Overall, this study suggests that self-regulated learning and direct instruction may be useful in increasing math word problem performance.
Preface

This thesis is original, unpublished work, primarily written by the lead investigator Nathalie Sagar. The study design and instructional procedures were collaboratively designed by the lead author and research supervisor, Dr. Sterett Mercer with input from Dr. Deborah Butler. Dr. Sterett Mercer was supervisory author on this project and was involved throughout manuscript edits. Data collection for this project was approved by the University of British Columbia’s Research Ethics Board (certificate no. H17-03472 and the Vancouver School Board’s Research Committee.
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Chapter I. Introduction

Math is a fundamental component of children’s education, as well as an essential skill for future learning that leads to competent and successful students and workers. Although math is a fundamental component of a child’s education many children have difficulty with math due to symptoms of math anxiety. Math anxiety is a state anxiety that is defined as a learned negative emotional reaction to situations involving mathematical tasks (Rossman, 2006; Young, Wu & Menon, 2012). Mathematical tasks encompass anything from entering a mathematical class, completing a mathematical test, to calculating the tip for a bill at a restaurant. The pervasiveness of math anxiety among students both young and old presents a serious obstacle in regard to both academic and professional outcomes. Specifically, Beilock and Willingham (2014) found that nearly half of all elementary age children experience math anxiety. Furthermore, math anxiety has several serious and long-lasting effects on not only one’s math ability, but also one’s self-confidence and professional success (Hembree, 1990; Young, Wu & Menon 2012). Despite the gravity and pervasiveness of math anxiety, there is currently no consensus on an intervention to mitigate its detrimental effects. However, a combined approach incorporating instructional and self-regulatory based components that promotes self-regulated learning may reduce math anxiety.

In the present study, I investigated a pilot series of lessons incorporating both self-regulated learning and schema-based math instruction to attempt to reduce the levels of math anxiety amongst early elementary grade students. Further, the lessons were used to foster motivation and positive attitudes felt by the students towards math. Finally, they were used to increase overall math performance on whole number word problems dissimilar to those completed throughout the intervention.
Chapter II. Review of the Literature

Importance of Mathematics

Research has consistently demonstrated that basic mathematical skills are necessary not only for students, but also for the general population to facilitate professional and personal success. For example, math performance and the number of math courses taken has been directly linked to the likelihood that one successfully graduates from their undergraduate degree, and to one’s future earnings when measured ten years after high school graduation (Rose & Betts, 2002). As evidenced by Rose and Betts’ research, math’s pervasiveness and role extends beyond academic development to encompass lifelong success and achievement.

Commonly within early elementary school grades the focus of the math curriculum is whole number computation. Within this there are three domains: understanding numbers, calculations, and word problems (Fuchs et al., 2014). Word problems present a critical aspect of math competence beginning at this age and remain imperative through adulthood. For example, it has been suggested that word-problem skill is one of the best predictors of school-aged children’s future employment and wages (Bynner, 1997). Word problems present as an area of difficulty for many students, as they require greater symbolic complexity and mental flexibility than other forms of math computation (Fuchs et al., 2014). Fuchs and colleagues (2014) argue that despite the evidenced importance of word problems, research regarding math interventions typically erroneously focuses on calculations.

Math Anxiety

Math is nearly universally disliked and an area of difficulty for many students. For example, Jackson and Leffingwell (1999) found that only 7% of Americans report having had positive experiences with mathematics through their entire academic career and Burns (1998)
found that two thirds of adults in the United States fear and loathe math. Further, research has found that 60% of undergraduate students suffer from symptoms of math anxiety (Perez-Tyteca et al., 2008). Typically, those who suffer from math anxiety avoid situations that require math and demonstrate poorer performance on mathematical tasks (Hembree 1990; Vukovic, Kieffer, Bailey & Harari, 2013). Therefore, it is evident that their math anxiety not only affects them emotionally while in math class, but also has the potential to affect their lifelong success and achievement.

The contributing factors which can lead to math anxiety have been divided into four broad categories. Environmental factors, such as the classroom environment, or the number of students in the testing environment; intellectual factors, such as cognitive capabilities or learning styles; internal factors, such as self-efficacy and self-esteem (Woodard, 2004) and a more recently found genetic component (Wang et al., 2014). The multifaceted causes of math anxiety have led to difficulty in creating a single preventative approach to reduce its prevalence and effects.

**Math self-efficacy and math anxiety.** Bandura (1977) proposed a theory of self-efficacy in which he defined self-efficacy as one’s beliefs regarding their own ability to successfully perform a task. Bandura argued that one’s self-efficacy will greatly impact whether a person will attempt a given task, how much effort they will spend on that task, and if they will persist when the task becomes difficult. According to social learning theory, math anxiety as a result of low math self-efficacy, therefore implying that the two concepts are related (Bandura, 1986). Paralleling this theory, Ahmed, Minnaert, Kuyper, and van def Werf (2012) sampled 495 grade seven students three times and found using as reciprocal relationship between math self-concept and math anxiety. Specifically, they found that lower levels of math self-concept
precited higher levels of math anxiety. Similarly, Skaalvik (2018) found that within 939 middle school students, the who avoided completing their math work to avoid demonstrating their incompetence or being negatively perceived by others predicted higher levels of math anxiety. This maladaptive coping mechanism for math anxiety is thought to be influenced by one’s math self-efficacy and again create a bidirectional relationship between math anxiety and math avoidance.

**Math anxiety and general anxiety.** Math anxiety produces physical symptoms similar to that of general anxiety such as nausea, increased heart rate, perspiration, and cognitive difficulties (Biggs & Preis 2011). Additionally, both math and general anxiety have been consistently shown to impair one’s working memory and implicate the amygdala, a brain region often associated with processing negative emotions and fearful stimuli (Young, Wu & Menon 2012). Math anxiety is correlated with both general and test anxiety; if one suffers from general or test anxiety they are more likely to suffer from math anxiety. However, it is an independent and situation specific trait; therefore, it is possible to suffer from only math anxiety and not test anxiety or general anxiety (Anton & Klisch, 1995).

Although producing similar symptoms, it has been consistently hypothesized that math anxiety is conceptually distinct from a generalized anxiety disorder (Dreger & Aiken, 1957). In bolstering this argument, a meta-analysis conducted by Hembree (1990) found that there was a correlation of 0.38 between math anxiety and generalized anxiety. This demonstrates that although individuals who are high in math anxiety may also be high in generalized anxiety, the two experiences of anxiety are separate constructs. Furthermore, it has been hypothesized that math appears to generate sufficient difficulty and apprehension that it could be considered an object of a genuine specific phobia. A specific phobia is a state anxiety reaction that is a
stimulus- and situation-specific learned fear which manifests in elevated cognitive and physiological arousal (Ashcraft & Ridley, 2005). In light of these findings, it becomes clear that one of the fundamental differences between math anxiety and generalized anxiety is that math anxiety is a form of state (momentary) anxiety, whereas generalized anxiety is an experience of trait (habitual) anxiety. Despite these fundamental differences, math anxiety is still very much comparable to generalized anxiety as it produces similar symptoms, and has a similar effect on one’s working memory. Therefore, the literature on interventions for both generalized anxiety and specific phobias should be investigated when looking to intervene on math anxiety.

**Bidirectionality of Math Anxiety and Math Performance**

It has been consistently demonstrated and is widely accepted that there is a negative relationship between math anxiety and math performance (Foley et al., 2017). However, presently, there is a lack of consensus on the directionality of this relationship. Specifically, it is debated as to whether math anxiety impairs math performance, poor math performance contributes to feelings of math anxiety, or the relationship is bidirectional. The aforementioned literature is illustrative of math anxiety causing poor math performance and implies math anxiety’s effect on one’s working memory as a factor in this relationship. However, research also has demonstrated that a poor understanding of basic math and math difficulties leaves students more vulnerable to developing math anxiety (Levine, Gunderson, Maloney, Ramirez, & Beilock, 2015). Foley and colleagues (2017) conducted a meta-analysis considering evidence supporting both sides of directionality, and concluded the relationship is bidirectional. The bidirectionality of math anxiety and math performance emphasizes the importance of investigating remedial interventions to treat math anxiety, as well as preventative measures that attempt to prevent feelings of math anxiety in younger students.
Math anxiety and working memory. Research has demonstrated that anxiety interferes with the functioning of one’s prefrontal cortex; this interreference, in turn, impairs one’s executive functions (Blair & Diamond, 2008). Executive functions are a variety of abilities that are imperative to mathematical success. Specifically, core executive functions include cognitive flexibility; inhibition, which encompasses self-control and self-regulation; and working memory. It has been hypothesized that the decrease in math performance in math anxious individuals is the result of one’s anxiety taxing their working memory while one attempts to compute the mathematical task (Ashcraft & Krause, 2007). Working memory is the component of short-term memory that is used with conscious perceptual and linguistic perception. It allows for the retention of information while one is occupied with another task. For example, suppose you are trying to find your way to a building; you stop and ask someone for directions. If this person first told you the address of the building, you would store that information in your working memory while you listened to their directions to said building. Working memory plays a vital role in math performance and cognition; processes such as carrying, multi-step problems, reconstructive strategies, the use of large numbers, and mental arithmetic all rely heavily on one's working memory (Ashcraft & Krause, 2007). Further, Musso, Boekaerts, Segers and Cascallar (2019) found that working memory also plays a strong role in one’s self-regulation. The importance of self-regulation in math will be further discussed below.

Math word problems involve multiple steps and problem solving; therefore, they are particularly vulnerable the negative impact of impaired working memory (Passolunghi & Seigel, 2001). Both generalized, and math anxiety have been consistently shown to disrupt working memory (Ashcraft & Kirk, 2001; Ashcraft & Moore, 2009; Engle, 2002; Young, Wu & Menon, 2012). For this reason, interventions specifically targeting math performance and math anxiety
should focus on math word problems, as within this problem type the negative effects of math anxiety are compounded.

**Importance of Early Intervention for Math Anxiety**

The treatment of math anxiety, although important at all ages, presents a unique opportunity within early grades. Treating math anxiety amongst early elementary students allows researchers to take a more preventative approach, before the negative effects compound. Math anxiety has been compared to a genuine specific phobia (Ashcraft & Ridley, 2005). Research has consistently demonstrated that it is imperative to treat specific phobias early as they often worsen overtime (Marks, 1987); thus, demonstrating the importance of early intervention for math anxiety. Similarly, Ramirez, Gunderson, Levine and Beilock (2012) argue that identification and treatment of math anxiety in children as young as grade one is imperative. They argue that these early anxieties may cumulate and lead students, including those with higher working memory and great potential, to avoid math. Further, in upper elementary the demands in math classes shift greatly for the students; the word problems that students are expected to complete become much more complex and difficult (BC Ministry of Education, 2015). Therefore, an intervention targeted at early elementary student’s word problems prior to this increase in difficulty presents an opportunity to take more of a preventative approach to math difficulties and math anxiety.

**Interventions for Math Anxiety**

As research regarding math anxiety has been ongoing for nearly 60 years, several various intervention approaches have been tried to decrease its negative impact on students (Dowker, Sarakr, & Looi, 2016). Although there is some overlap, the majority of the interventions that have been investigated can be split into two areas of focus: social-emotionally focused interventions and instructionally focused interventions.
Social–emotionally focused interventions for math anxiety. Due to math anxiety’s similarities to generalized anxiety, previous literature has looked to interventions for generalized anxiety and specific phobias to reduce math anxiety. Specifically, expressive writing, a technique demonstrated to reduce generalized anxiety was shown by Park, Ramirez and Beilock (2014) to reduce the achievement gap between high and low math anxiety individuals. In their study, they randomly assigned students to an expressive writing group or a control group before an exam. Those in the expressive writing group were asked to write about their ‘deepest thoughts and feelings about the upcoming math exam’ for seven minutes. They found that for individuals with high math anxiety the expressive writing assisted in increasing their math performance.

Additionally, Jamieson and colleagues (2010) found that guided reappraisal of arousal, or symptoms of math anxiety, while writing a high stakes math test (the Graduate Record Examination, GRE) improved performance within 60 participants. Participants were randomly assigned to the guided reappraisal condition and a control group. Those in the reappraisal condition were told that feelings of anxiety have been found to increase performance, and that if they find themselves feeling anxious during the test that they should remind themselves that their arousal is assisting them to perform better. Participants in both groups then completed practice questions for the examination. Participants then reported back their GRE scores from their testing which they took within three months of the initiation of the study. It was found that participants in the reappraisal condition performed significantly better on both the practice problems (Cohen’s $d = 0.82$) and on the actual GRE (Cohen’s $d = 0.89$) than the control group on the math section.

Although addressing specific symptoms pertaining to math anxiety is important, additional psychological variables such as attitude, persistence, self-confidence, self-concept and
self-efficacy also significantly contribute to ratings of math anxiety (Hoffman, 2010). Therefore, interventions investigating the aforementioned psychological variables pertaining to math anxiety may demonstrate greater efficacy in reducing students’ experiences of math anxiety.

**Self-regulation and math.** Self-regulation is a broad construct that refers to one’s ability to control their own thoughts, feelings and actions (Zimmerman, 2008). One of the core principles of self-regulation in learning is making learning visible to students and encouraging them to become independent and creative learners. The nature of self-regulation lends itself well to bridging social emotionally focused interventions and instructional interventions for math anxiety. Definitions of self-regulated learning vary depending on the researcher’s theoretical perspective. However, definitions consistently reference self-oriented feedback during learning and the involvement of components such as: responding to environmental demands and controlling cognition, motivation, goal setting, and appropriate strategy use (Butler, Schnellert & Perry, 2016). Butler, Perry, and Schnellert (2016) parse out self-regulation as the integration of three dimensions: (1) motivation and emotion, (2) cognition and metacognition, and (3) strategic action.

Motivation and emotion encompass a student’s drive to engage in an activity and their affective responses when engaging in said activity. The most commonly known and practiced component of motivation and emotion is goal setting. Cognition refers to how a student thinks within activities; whereas meta-cognition refers to one’s knowledge, control and awareness about their cognitions. Meta-cognition encompasses components such as knowing your strengths and weaknesses as a learner, knowing the strategies you have at your disposal, and then managing your engagement with your knowledge and strategies to make decisions on how to best approach a task (Flavell, 1979). Both cognition and metacognition play a role in a student’s engagement
and motivation. Finally, strategic action involves interpreting task criteria, planning strategies, using strategies, monitoring previous strategy use, and adjusting future strategy use as necessary. These three dimensions work together to make up self-regulation.

The relationship between self-regulation and academic achievement is well evidenced and has led many educators to incorporate self-regulated learning into their classrooms (Schunk, 2005). Self-regulated learning has been integrated across many subjects; however, it is not as commonly seen within math classrooms (Dignath & Bütner, 2008). Specifically, Descortes and Verschaffel (2011) argue that within today’s math classrooms, external regulation by teachers is much more prominent than self-regulation.

Despite the lack of integration of self-regulated learning into today’s math classrooms, previous research has found links between self-regulation and mathematics in general. For example, Schunk (1998) found that weak self-regulatory skills were related to low motivation and learning in mathematics. Furthermore, Zimmerman and Risemberg (1997) demonstrated that students who succeed in mathematics possess several skills and abilities that are associated with self-regulation. These skills are managing study time; setting of specific, high, and attainable goals; monitoring their learning; problem solving with greater accuracy; and possessing greater self-efficacy and motivation. Finally, math problem solving has been found to require high levels of self-regulation (De Corte et al., 2011). In sum, it is evident that self-regulation is a relevant component to productive mathematics learning. However, research has shown that students do not become self-regulated learners intrinsically or automatically (Schunk, 2001); therefore, it is a skill that we must foster and teach to today’s students.

Questions with regard to the onset and development of self-regulation have been researched to provide insight into at which age we should begin to try to foster these skills in
children. Specifically, concerns with regard to a young child’s ability to development of self-regulatory skills have been posed due to concerns with their limited verbal abilities (Kreutzer et al., 1975) and working memory capacities (Blöte et al., 1999). In order to investigate this, Whitebread and colleagues (2009) coached teachers to observe 1440 children aged three to five years old. Their research found that there were both verbal and nonverbal indicators of self-regulatory processes such as metacognition within these students. Similarly, a meta-analysis conducted by Hamoudi, Murray, Sorenson, and Fountaine (2015) concluded that parenting factors can impact the development of self-regulation as early as early infancy and toddler-hood. These findings suggest that although self-regulatory abilities continue to improve and develop as a child ages (Kuhn, 2000), they are skills we can teach and encourage early on in a child’s development.

Previous interventions have directly taught specific components of self-regulated learning to increase overall math performance. Specifically, promoting cognitive components such as self-efficacy has been shown to have this effect (Fuchs et al., 2003; Schmitz & Perels, 2011; Schunk & Cox, 1986; Schunk, 2008). Additionally, Schmitz and Perels (2011) used standardized diaries that incorporated key cognitive components of self-regulation to increase self-regulatory behaviour and math learning in 8th grade students; however, the effect sizes were quite small (partial $\eta^2$ ranged from .02 to .06). Additionally, Fuchs and colleagues (2003) found that goal setting and self-evaluation positively affected problem solving in grade 3 students. These interventions demonstrate that one can integrate self-regulated learning into math interventions and increase students' math performance and overall self-regulatory abilities.

Previous literature supports the hypothesis that self-regulation may not only be useful in increasing math performance, but also in reducing mathematics anxiety. Specifically, Özcan and
Gümüş (2019) found that metacognition had a direct effect on math problem solving performance ($R = 0.50$), finding that it mediated the effects of self-efficacy, motivation, and math anxiety in 517 seventh grade students in Turkey. Further, Tobias (1995) found a significant negative correlation between scores on math anxiety and scores on metacognition, a component of self-regulation ($R^2 = 0.42$). After investigating first and second grade students with math anxiety, Ramirez, Chagen, Maloney, Levine and Beilock (2015) echoed previous literature in suggesting that teaching students’ self-regulatory skills such as using math strategies more effectively will not only assist in teaching math content but will also assist in alleviating symptoms of math anxiety when engaging in math tasks. Further, Jain and Dowson (2009) found that motivation mediates the relationship between cognitive self-regulation and anxiety, suggesting that motivation is another central component to decreasing mathematics anxiety. Exploring the incorporation of self-regulated learning into mathematical interventions to not only increase mathematical performance but also to decrease math anxiety may push the literature on math anxiety forward. Furthering this logic, Jain and Dowson (2009) modeled math anxiety as a function of self-regulation and self-efficacy.

In sum, the aforementioned interventions support the exploration of math anxiety through its roots in self-regulation in as an alternative method of treatment that may show greater efficacy than previous attempts treating it as generalized anxiety. More research is necessary investigating self-regulated learning as a means to target math anxiety in addition to mathematical performance.

**Instructional interventions for math anxiety.** Typically, the math anxiety literature has focused on social emotional interventions for math anxiety, whereas instructional interventions are typically explored within the math difficulty and math learning disability literature. As math
anxiety and math difficulty consistently go hand in hand (Foley, 2017), looking to instructional interventions for math performance may prove useful in generating interventions for math anxiety.

**Schema based instruction.** Schema based instruction is a promising way to assist in solving word problems for students with math difficulties. It has been demonstrated to be an effective intervention for students with math difficulties, including those with a specific learning disability in math (Fuchs et al., 2004; Jitendra et al., 2013; Jitendra, Dupuis, Star, & Rodríguez, 2014; Jitendra, Harwell, Dupuis, & Karl, 2016). Further it is embedded in empirically supported word problem interventions, such as Pirate Math (Fuchs et al., 2008). It is a multi-component mathematics intervention that emphasizes the structure of math problem solving through the use of schematic diagrams. Although it is not completely aligned with self-regulated learning, it incorporates problem solving and metacognitive strategy instruction as it provides student with a heuristic to self-monitor and assist in math problem solving (Jitendra, Dupuis, Star, & Rodríguez, 2014). This fosters metacognition, reflection, strategy use and problem solving. Schema based instruction is an instructional intervention for math anxiety that appears to be promising for a combined math anxiety intervention using both instructional and social-regulation components. Thoughtfully and intentionally integrating a broader scope of self-regulation into this already promising technique may prove extremely beneficial for students with math difficulties and symptoms of math anxiety.

**Present Study**

To date, few studies have utilized a combined instructional and self-regulatory intervention to decrease math anxiety. The present study contributes to the literature regarding math anxiety by integrating a broader scope of self-regulation components with an existing and
effective mathematical intervention, schema based instruction, to target math anxiety and math performance in elementary students. The present study investigated the efficacy of a novel series of pilot lessons that use self-regulation and schema-based math instruction with grade one and two students. The goals of the lessons were to increase math performance and strategy use for elementary aged students, while simultaneously decreasing negative emotions felt prior to, during, and after completing a difficult math task (math anxiety).

The series of lessons on whole number addition and subtraction word problems incorporated schema-based instruction, adapted from Jitendra (2007), with additional facets specifically aimed at increasing self-regulated learning. Self-regulated learning was incorporated in three ways. First, students were given the choice of three overarching themes that will be consistent across all lessons. The choices for arching themes provided to the students were a visit to the zoo (chosen by one student), fairy tales (chosen by three students), and an adventure under the sea (chosen by no students). These overarching themes were designed with the intention to increase motivation and engagement within the students. Giving choice supports autonomy within the students and promotes the feeling that they are in control over their learning. From a motivational perspective, as well as research investigating increasing student autonomy, tasks that are regarded as meaningful by students (i.e., tasks that relate to their past experiences, connect to their interests, and have real implications for their learning) foster self-regulated learning and mathematical achievement through this increased engagement and motivation (Berliner, 1979).

Secondly, interpreting the word problem and defining the task criteria were explicit learning objectives of each lesson. This learning objective encouraged students to use the strategic content learning (SCL) approach. The SCL approach is a model of learning designed
within a model of self-regulation (Butler, 1998; Butler & Winne, 1995). Within SCL, instructors support students as they practice metacognitive tasks central to self-regulated learning such as goal setting; selecting, adapting, and inventing strategies; and monitoring progress. The support provided by the instructor is largely dialogic based and pushes the student to explain or adapt their thinking. Research has found that not only is SCL consistent with self-regulated learning, but it also assists students in becoming more self-regulated in their learning (Butler, 1995). Specific to math, Butler, Beckingham, and Novak Lauscher (2005) suggest that SCL fosters both domain-specific knowledge about math concepts, in addition to understanding about what is required to be an effective learner in math. Specifically, they note that SCL fosters skills within students to self-direct their learning of math in areas that they have difficulty while also fostering self-regulation skills. Consistent with SCL, prior to engaging in the instructional component of the schema-based instruction, a guided exploratory process was used to create opportunities for students to practice defining task criteria and identifying strategies. The goal of these explicit learning strategies was to help the students to learn and develop strategies and schemas that they can use in future math problem solving.

Thirdly, students self-assessed outcomes and revised their work throughout the problem solving and strategy use with the instructor and at the end of each session. When through problems with the instructors the students dynamically self-assessed each question at a time so that they could apply what they learnt to the next problem. Self-assessment simulates reflection and knowledge of what is known, what requires further work, and what skills and strategies were effective; thus Zimmerman (2000) argues that self-assessment fosters planning and regulation of future use of self-regulated learning. Specifically, in this study students completed a session reflection form at the end of each session. The self-reflection form will be an adapted version of
Schmitz and Perels (2011) standardized diaries used with grade eight students. Finally, students completed a questionnaire regarding their emotions, self-efficacy, and appraisals of successes and failures which simulated reflection and metacognition. Metacognition has been found to enable students to reflect on their accomplishments, more effectively monitor their learning progress, and to self-assess their performance; these are core components of self-regulated learning (Paris & Paris, 2010).

**Hypotheses**

I hypothesized that targeting math anxiety and performance through an integrated series of lessons that targets self-regulation and specific math strategy use for word problems will result in several positive effects. Specifically, it was hypothesized that the intervention will (a) decrease self-reported levels of math anxiety, while also (b) increasing mathematical performance on whole number math word problems. Additionally, secondary dependent measures were collected to explore the possibility of (c) increasing self-reported levels of math self-efficacy and motivation, and (d) improving performance on measures of applied mathematical problem solving dissimilar to the word problems used throughout the intervention.
Chapter III. Methodology

Participants

The participants in this study were two grade one students and two grade two students (for a total of four participants) who had no diagnosed learning disability attending a public elementary school in Vancouver, British Columbia. These students were selected by their teachers if they were identified as having difficulty with grade level mathematics and math word problems, as well as demonstrating symptoms of math anxiety, negative math attitudes, and/or low math motivation. It is important to note that all of the participants also participated in a school wide self-regulatory intervention, Zones of Regulation (Kuypers, 2011) prior to the present intervention. Zones of Regulation is a framework that aims to teach students to become aware of and better able to regulate their emotions. Research has demonstrated that it has resulted in some improvements in a student’s self-regulatory abilities, but not to a clinically significant degree (Valkanos et al., 2016). After obtaining parental consent and student assent, I then screened the participants and collected demographic information from the participant’s parents. See Table 1 for the results of the demographics questionnaires. The names of the participants have been changed to pseudonyms to ensure confidentiality.

Table 1.

Student Demographics

<table>
<thead>
<tr>
<th>Student</th>
<th>Grade</th>
<th>Ethnicity</th>
<th>Primary Language</th>
<th>Other Languages</th>
<th>Caregiver’s Education</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hanna</td>
<td>2</td>
<td>First Nations</td>
<td>English</td>
<td>Cree (25%)</td>
<td>C1: Grade 10</td>
</tr>
<tr>
<td>Theo</td>
<td>1</td>
<td>Sri Lankan</td>
<td>Tamil</td>
<td>English</td>
<td>C1: High School Diploma</td>
</tr>
<tr>
<td>Penelope</td>
<td>1</td>
<td>Chinese and Japanese</td>
<td>English</td>
<td>n/a</td>
<td>C1: Undergraduate Degree</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>C2: Undergraduate Degree</td>
</tr>
<tr>
<td>Michael</td>
<td>2</td>
<td>First Nations</td>
<td>English</td>
<td>Gitkson (25%)</td>
<td>C1: College</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>C2: Grade 10</td>
</tr>
</tbody>
</table>
The demographics questionnaires indicated that two of the participants identified as First Nations, one as Sri Lankan, and one as Chinese and Japanese. While all of the participants' schooling was in English, one of the participants’ primary language spoken at home was not English, and two participants spoke other languages in the home approximately 25% of the time. Theo participated in the Reading Recovery program for 30 minutes twice a week as part of the English Language Learners program through his school. Theo had been participating in this English language instruction since he was in Kindergarten. Participant’s caregiver education varied from Grade 10 high school to undergraduate degrees.

The eligibility criteria of the students were twofold. Firstly, to be deemed eligible to participate in the study participants’ scores on a measure of cognitive functioning, the Kaufman Brief Intelligence Test, Second Edition (KBIT-2; Kaufman & Kaufman, 2004), could not fall below two standard deviations of the mean. Finally, students were required to demonstrate basic number sense using the Test of Early Mathematics Ability, Third Edition (TEMA-3; Ginsburg & Baroody, 2003). Participants were not required to demonstrate mastery on procedures for adding or subtracting two-digit numbers, as it was believed that students who lacked this skill would gain it during the intervention. Additionally, screening information with regard to student’s reading skills were assessed based on the beginning of grade one benchmark of the DIBELS Oral Reading Fluency reading passages (Goods & Kaminski, 2002) to inform program planning.

Measures

To ensure that students met inclusion criteria for the study, measures of cognitive functioning, and number sense were administered as part of the initial screening process. Additionally, further screening information was collected on the participant’s reading level to further investigate their challenges with math word problems. During the intervention,
researcher-generated math word problems and an adapted math anxiety questionnaire were used to continuously monitor the student’s performance as primary dependent variables. Finally, students completed pre- and post-intervention measures of math self-efficacy, math motivation, and applied mathematical problem solving. Although causal inferences cannot be made on the secondary dependent variables due to the sample size and design of the study, they provide descriptive insight into the intervention’s effects beyond the dependent variables.

**Cognitive functioning.** The Kaufman Brief Intelligence Test, Second Edition (KBIT-2) is a commonly-used brief norm-referenced measure designed to screen the cognitive functioning of individuals aged 4.0 to 90.11 (Kaufman & Kaufman, 2004). The KBIT-2 involves completion of three subtests in approximately 15 minutes. The KBIT-2 has strong psychometric properties; specifically, it has been reported to have strong levels of reliability (internal consistency of 0.93, test-retest reliability of .90) and strong correlations with other intelligence and achievement tests (Kaufman & Kaufman, 2004).

**Basic reading skills.** Research has demonstrated that oral reading fluency is an accurate overall indicator of reading ability and development (Fuchs, Fuchs, Hosp & Jenkins, 2001). Therefore, participants’ basic reading skills was assessed using DIBELS Oral Reading Fluency (Goods & Kaminski, 2002). This task measures a student’s ability to accurately and quickly read connected text. DIBELS Oral Reading Fluency is a commonly used brief measure of reading ability and has strong reliability and validity (Goffreda & Clyde, 2010).

**Basic math skills.** The Test of Early Mathematical Abilities, Third Edition (TEMA-3) is an individually administered norm-referenced test used to assess math performance in young children (3.0-8.0). The TEMA-3 was standardized on a sample of 1,219 children whose characteristics approximately matched the 2001 U.S. census. Internal consistency reliabilities
were all above 0.92 and many studies were conducted which demonstrated the validity of the TEMA-3 (Ginsburg & Baroody, 2003).

**Math word problems.** Researcher-generated math word problems were the primary measure of the dependent variable in the present study. Throughout the intervention students were taught three different strategies corresponding with three types of word problems. The three types of math word problems were: change problems, group problems, and compare problems. In a change problem, there is a beginning amount, a change action, and a different amount in the end. In a group problem, there is a large group that is equal to the sum of smaller parts. Finally, compare problems are math word problems that tell about the sameness or difference between two things or groups (Jitendra 2007). An example of each problem type can be found in Table 2. below.

Table 2.

*Example of Each Problem Type*

<table>
<thead>
<tr>
<th>Problem Type</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change</td>
<td>At the beginning, the zoo had 11 lions. If they got 4 more lions, how many will they have in the end?</td>
</tr>
<tr>
<td>Group</td>
<td>Theo saw 17 animals. 5 of the animals were sealions. How many of the animals were not sealions?</td>
</tr>
<tr>
<td>Compare</td>
<td>The zoo has 13 sharks. The zoo has 6 more dolphins than sharks. How many dolphins does the zoo have?</td>
</tr>
</tbody>
</table>

The word problems were adapted versions of questions from Jitendra’s (2007) *Schema Based Instruction*, as well as Jordan and Hanich’s (2000) Story Problems, the Iowa Story
Problems (Hoover, Hieronymous, Dunbar, & Frisbie, 1993), and Vanderbilt Story Problems (Fuchs, 2009). These questions contained similar words and syntax to ensure they were consistent in language complexity and all contained numbers less than or equal to 20. Further, these math world problems were designed to align with the student’s selected overarching theme and included the student’s name to foster engagement and motivation.

Participant’s performance on each word problems were scored out of two possible points. Participants were rewarded one mark for calculating the correct answer to the math question, and one mark for showing their work and engaging in use of a strategy (i.e. writing out a schema, using tic marks, drawing pictures). Awarding students marks for showing their work is common practice in math education and has been used to award students for demonstrating a knowledge of the conceptual underpinnings of the math question, even if the computation itself may be incorrect. For example, on the numeracy assessments used in the province of British Columbia, students are marked for their correct answer and showing their work (British Columbia Ministry of Education, 2017). Further, as math anxiety and math self-concept are related to challenges with task- initiation (Bandura 1977) and performance avoidance (Skaalvik, 2018) students showing initiation of the task and an attempt at beginning the work or engaging in a strategy demonstrates that they may have overcome the initial hurdle of math anxiety.

**Math anxiety.** At the end of every session students completed a brief reflection handout that incorporated facets of Schmitz and Perels (2011) standardized math diary and the Math Anxiety Scale for Young Children – Revised (MASYC-R; Ganley & McGraw, 2016). The MASYC-R was adapted such that the questions were written in such a way that children will reflect on the intervention session that just occurred, as opposed to their entire academic experience with math. For example, “Math gives me a stomach ache” was changed to “Doing
math today gave me a stomach ache”. The MASYC-R has strong reliability and validity, and it is believed that the slight changes in wording did not significantly affect these psychometric properties.

**Applied mathematical problem solving.** Applied mathematical problem solving was measured using the two applied problems (word problem) subtests from the KeyMath-3 (Connolly, 2007). These subtests are applications of problem solving, and foundations of problem solving. The KeyMath-3 is a norm-referenced measure of mathematical abilities. It was designed to assess math skills in students aged 4.6 to 21.0. The KeyMath-3 comes in two different forms allowing for administration at two different time points with fewer practice effects. Finally, the KeyMath-3 has strong levels of reliability (0.97) and validity.

**Math self-efficacy and motivation.** Math self-efficacy and motivation was assessed just prior to and after intervention using a researcher adapted version of the Motivated Strategies for Learning Questionnaire (MSLQ; McKeachie, Pintrich, & Lin, 1985). The original MSLQ is a 55-item questionnaire consisting of 10 different scales for middle school students. The MSLQ is a commonly used measure internationally (Duncan & McKeachie, 2005; Pintrich et al., 1987). For the purpose of this study, select scales (the motivational scales and cognitive and metacognitive subsection) were used. The reliability coefficients of the motivational scales ranged from 0.62 to 0.93, and the reliability of the metacognitive self-regulation subscale’s reliability was 0.79. Some of the questions within these scales were adapted such that the language was appropriate for grade one and two students. For example, “I’m confident I can understand the most complex material presented by the instructor in this course” was changed to “I am sure I can understand the hardest parts of our math class.” A copy of the adapted version of this questionnaire can be found in Appendix D.
**Social validity.** At the end of the intervention a social validity questionnaire was given to the participants and their teacher asking if they felt the intervention assisted with the students’ (a) math word problem performance, (b) symptoms of math anxiety, and (c) overall math performance. These questions were asked on a five-point Likert scale ranging from strongly disagree to strongly agree. Measuring socially validity provides insight into if the intervention is seen as useful by the teaching professionals working directly with the students on a daily basis, and the students themselves.

**Procedures**

**Recruitment and screening.** A teacher was asked to put forth students (4 students total) who the teacher identified as having difficulty with math word problems, as well as demonstrating symptoms of math anxiety, negative math attitudes, and/or low math motivation. Signed informed parental/guardian consent and student assent were obtained by the teacher. Once consent and assent were obtained, students were screened using the KBIT-2, DIBELS Oral Reading Fluency, and TEMA-3. During baseline data collection it became evident that one participant was competent in math word problems and able to independently implement effective strategies to solve math word problems. Further, this participant reported high levels of math self-efficacy and low levels of math anxiety. For these reasons the intervention was deemed inappropriate for said participant. A letter was sent home to this participant’s parents explaining why their child was no longer participating in the study which included recommendations for specific areas of difficulty that the child had. The teacher was asked to put forth a fifth student at this time. Signed parental/guardian consent and student assent were obtained by the teacher for this student, and the screening process began.
Once determined that the students meet inclusion criteria, parents were asked to complete a short demographics questionnaire. At this time, students met with the researcher for the first time and were told that they were going to be working on some math problems together throughout the school year. The student was told that they had a choice of three overarching themes for their work together to be based on. The choices for arching themes provided to the students were a visit to the zoo (chosen by Theo), fairy tales (chosen by all other students), and an adventure under the sea (chosen by no students). These overarching themes were designed with the intention to increase motivation and engagement within the students. Once chosen, the word problems for all following sessions were related to these overarching themes.

**Experimental design.** The effects of the math anxiety intervention that incorporated instructional components (schema-based instruction) as well as self-regulated learning were evaluated using a multiple probe across students design. The independent variable in this study was participation in the combined intervention for math anxiety. The intervention itself targeted three question types: change problems, group problems, and compare problems. The primary dependent variables were math performance on word problems and self-reported levels of math anxiety. Secondary dependent variables were student math self-efficacy, motivation, and applied mathematical problem solving on general math word problems.

In this design, students act as their own comparison as they begin the intervention at different time points. The present study had a baseline condition and three intervention phases that corresponded to three problem types. During the baseline condition, students participated in regular classroom instruction and progress monitoring data were collected on student math word problem skills and levels of math anxiety. Further information regarding progress monitoring will be detailed below.
Intervention sessions were introduced to participants at staggered time points after stable baselines were observed. For Hanna (participant 1), a stable baseline was observed after 3 data points; therefore, the intervention began on the fourth session. Intervention sessions occurred one on one with each student in a quiet room three to five times a week for approximately half an hour. Once the first probe was administered to Hanna it was not administered to Theo (participant 2) until (1) Theo demonstrated 3 data points of stable responding to phase 1 of the intervention. This again occurred with P2, P3 and P4. Once a stable change was found in Hanna’s performance for the change problems, she entered the second intervention phase for compare problems. This continued across participants, and then again for the third problem type, group problems. Due to an extended number of consecutive absences in participant 3 (Theo), the intervention was started with participant 2 (Penelope) after only 2 overlapping data points. Due to a delayed start with the fourth participant (Michael), extended absences, and the end of the school year, he was unable to complete all three problem types.

**Progress monitoring.** Student progress in math word problem performance was measured at the end of each session using researcher generated word problems specific to the problem type the student encountered that session. Student’s performance was marked out of 2 possible points. Students received one point for finding the correct answer and one point for showing their work and engaging in strategy use. Acceptable strategies included: drawing a number line, drawing tic marks or physical representations of the items in the problem, and drawing a schema as taught in the lesson. Throughout the intervention, intermittent probing was done on previously taught problem types to check for maintenance of learning. At the end of every session students also responded to the brief reflection and math anxiety questionnaire.
**Baseline.** During the baseline phase of intervention, students participated in typical classroom instruction. In class instruction at the time of the intervention included instruction surrounding fluency of computing addition and subtraction with numbers up to 10 students were taught addition and subtraction with numbers up to 10 and identifying changes in increasing patterns. Although typical classroom instruction addressed fluency of math computations it did not address word problems similar to those used in the intervention. Data were collected three times a week on their feelings and math motivation, math word problem performance across all three problem types, and feelings of math anxiety.

**Combined intervention.** Students participated in a math anxiety intervention that combined both instructional and social-emotional components. This intervention used schema-based instruction as well as core components of self-regulated learning. The intervention consisted of several sequential components: Before Today’s Session questionnaire, guided exploration, direct instruction, progress monitoring, and Revise and Reflect. See appendix E for a sample lesson plan. In considering the aforementioned relation between symptoms of anxiety, working memory, and math performance, many accommodations were incorporated into the intervention to account for potential deficits in working memory that may have been experienced by the participants as a result of their symptoms of anxiety. Specifically, oral directions were kept short, simple, repeated as necessary, and were chunked, it was ensured that directions were understood, and directions were provided in writing to provide something for the participants to go back to. Finally, the intervention itself included visual organizers for the information that could help the participants that would help support the student’s working memory.

**Before Today’s Session.** The intervention began by completing a brief “Before Today’s Session” questionnaire that assessed the student's feelings and motivation for that day.
Specifically, this questionnaire used three visual analogue scales using pictures on a continuum to ask students if they are in a good or bad mood, if they are motivated or not to do math, and if they are feeling awake or tired. This questionnaire provides insight into student attitudes towards the intervention and math word problems throughout the intervention, as well as factors which may have impacted their performance throughout that session. See Appendix A for this questionnaire.

**Guided exploration.** For the guided exploration portion of the intervention the researcher and student looked at the word problems together and used guided exploration to aid the student in determining what the question was telling them, what the question was asking, and how they might solve the word problem. The researcher guided the student to reflect on these questions for approximately 2 minutes, querying the student as needed with the following probes: “What do you think the question is asking you to do?”, “What can you do to find the answer?”, “Tell me more about that”, and “What has worked before?”. Throughout these two minutes, the researcher examined the student’s responses and reflected on their similarities to the strategy that was to be taught that session.

**Direct instruction.** After the two minutes of guided exploration the researcher tied the student’s strategy to the strategy that was going to be taught and pointed out the similarities and differences. For example, the researcher would say, “I like how you circled the numbers that were in the questions. Some students, after they circle the numbers, write them down like this to help them find the answer.” In the case that a student generated a variation of a taught schema the student was still shown the suggested strategy but encouraged to use whichever strategy they preferred. For example, two participants generated schemas very similar to the taught ones but preferred to stack the numbers vertically rather than horizontally. One student (Hanna) coined
doing it this way the “The Hanna Way” and often completed problems this way without any issue. The researcher and student then worked through three problems together, following a modified version of the steps outlined in Jitendra and colleagues’ (2014) schema-based instruction. The steps involved having the student retell the story in their own words, identify what the problem is asking, organize the information from the word problem, underline key words in the word problem, circle the numbers, and check that the answer they get makes sense. Throughout direct instruction students were probed to self-evaluate their strategy use and reflect on what worked for past question, using the same queries described in the guided exploration.

**Progress monitoring.** The student then completed three word problems of the same type on their own which served as the progress monitoring. Students’ performance was marked on strategy use and obtaining the correct answer

**Revise and reflect.** Once the student completed progress monitoring, the student, with the assistance of the instructor, self-assessed their strategy use and performance on the math problems. If the student got a question wrong, they were encouraged to try different strategies as necessary with assistance until they found the correct answer. The student was told if their answers were correct or “that’s not quite right.” The researcher then queried the student as needed with the similar probes as during the guided exploration to help them to reflect on their work: What did you do to find the answer?”, “What do you think the question is asking you to do?”, “What did we do before to find the answer?”, “What are some steps we did before to find the answer?”, “Tell me more about that”, and “What has worked before?” The student then completed the reflection handout that measured their feelings surrounding the day’s session, their feelings of math anxiety, and the strategies used in the session. This handout can be found in Appendix B.
**Maintenance.** Approximately three sessions (typically one week) after each student entered the second and third intervention phases, they were reassessed on the previous problem type to check for retention of learning on that specific problem type. If it was found during a maintenance session that a student’s progress was regressing on a previous problem type, review sessions were built into future sessions to bring the student’s progress back up to previous intervention levels. This occurred twice for one participant, Michael. Sessions where review was provided are marked on the graphs with an asterisk.

**Integrity of implementation and inter-scorer agreement.** The researcher worked with students during both the baseline and intervention phases. The researcher was thoroughly trained on the implementation of the intervention had templates for each lesson to ensure that each step was met. Finally, one third of all sessions were randomly selected and recorded to be reviewed by third parties to measure inter-observer agreement across baseline and intervention phases.

The implementation of the intervention was monitored by the audio recordings to ensure fidelity of the intervention. The reviewers were graduate students who were trained on the general outline of the intervention and provided with a sample lesson plan. This lesson plan be found in appendix E. The reviewers had a checklist which they used while listening to the recorded sessions to ensure that all steps of the interventions were met. This checklist can be found in appendix F. The raters listened to one third of the sessions across baseline and intervention and marked on a checklist when each of the steps of the intervention occurred. Interrater reliability was then calculated by dividing the total number of observed steps observed by the rater t by the total steps and multiplying the result by 100%. The mean score across participants was 99%.
For the randomly selected recorded sessions the reviewer scored the math anxiety questionnaire and the progress monitoring problems done in those sessions without knowing the first examiner’s scoring. The raters were provided with a marking key for the math anxiety questionnaire and were trained on the marking of both the math word problems and math anxiety questionnaire. The inter observer reliability was then calculated by dividing the number of remarked items that agreed with the primary researchers scoring by the total number of remarked items and multiplying the result by 100%. The overall agreement score was 99%.

Kratochwilll and colleagues (2013) is best practice that a minimum acceptable percentage of agreement for inter observer agreement range between 80 to 90%. Therefore, it is evident that for both the fidelity of implementation and the marking of items there is deemed sufficient.

**Data analysis.** The primary dependent variables (word problem performance and self-reported math anxiety) were graphed and visually analyzed. Visual analysis involves considering potential changes in level, trend, and variability from baseline to intervention across participants and within participants across problem types. Kendall's rank-order correlation τ, τ test of statistical significance was then calculated as a supplement to the visual analyses, quantifying the overlap between baseline and intervention data points. Further, the τ test of statistical significance was used in order to calculate an effect size in order to better understand the strength and direction of the effect of the intervention on math performance and math anxiety. These procedures follow those outlined by Tarlow (2016). The performance of the four students was examined to determine if a similar pattern of response was documented across participants on dependent variables to ascertain whether there were three evident functional effects to evidence experimental control. A minimum of three demonstrations of change across three points in time has been cited as necessary to demonstrate experimental control (Horner, Carr, Halle, McGee,
Odom, & Worley, 2005) The secondary dependent variables were analyzed descriptively to look for overall changes. As these variables were not repeatedly assessed throughout the intervention, they cannot be analyzed using group statistics to inform causal inference; however, means and standard deviations can provide information on general trends regarding the impact of the intervention. The descriptive statistics of the student and teacher responses on a measure of social validity administered following the completion of the intervention were also analyzed.
Chapter IV: Results

Screening Assessments

Screening results for the selected students are reported in Table 3 below.

Table 3.

<table>
<thead>
<tr>
<th>Student</th>
<th>KBIT-2 (SS)</th>
<th>TEMA-3 (SS)</th>
<th>Reading Level (beginning of grade one benchmark)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hanna</td>
<td>96</td>
<td>84</td>
<td>Low Risk</td>
</tr>
<tr>
<td>Theo</td>
<td>99</td>
<td>86</td>
<td>At-Risk</td>
</tr>
<tr>
<td>Penelope</td>
<td>85</td>
<td>86</td>
<td>Low Risk</td>
</tr>
<tr>
<td>Michael</td>
<td>96</td>
<td>71</td>
<td>At-Risk</td>
</tr>
</tbody>
</table>


Results of the Kaufman Brief Intelligence test indicated that all four participants’ scores were within the average range. Results from the TEMA-3 indicated that all of the participants demonstrated Low to Low Average performance in regard to their early mathematic skills, with Michael’s demonstrating the greatest difficulty in this area. However, error analysis and informal assessments indicated that all participants possessed the necessary basic skills for the intervention. The informal assessments included asking students to orally count, asking students to demonstrate knowledge of cardinality by asking them to identify how many counters were in different groups, and understand relative magnitude by identifying which quantity is greater amongst a group of choices. Finally, the DIBELS Oral Reading Fluency assessment indicated
that two participants (Hanna and Penelope) indicated no concerns with regard to their reading fluency. Theo and Michael were both in the At-Risk range, demonstrating significant difficulty with reading. As the questions were read aloud for all participants, and both these participants presented as students who would otherwise benefit from the intervention, it was determined that these students could participate in the intervention without accommodations or modifications.

**Math Performance**

To assess the intervention’s impact on math word problem performance, gains in math word problem solving (problems correct) and strategy use (one point for showing their work and engaging in use of a strategy) were measured and monitored throughout the study. Students’ performance in math word problem performance are presented in Figure 1 below.
Figure 1. Student’s math word problem performance across baseline and intervention. Math word problem performance was determined by participant’s performance on three word problems. Students received one point for finding the correct answer and one point for showing
their work and/or engaging in strategy use. Sessions marked with an asterisk (sessions 24 and 25 for Michael) indicate that review was provided for previously taught problem types after progress monitoring data was collected.

A visual analysis of Hanna’s data shows few instances of overlapping data points between baseline performance and each problem type after intervention. Specifically, for change problems Hanna only 1 of 13 (7%) of intervention data points overlapped with the baseline. For group and compare problems, no data points (0%) overlapped with the baseline. There was minimal change in level across problem types until that specific problem type was taught. This slight improvement does not overlap with the post-intervention data points, indicating that there was still a greater improvement when compare problems were intervened on. The visual analysis demonstrates a clear change in level and trend from baseline to intervention for each problem type, indicating three demonstrated basic effects across skills within Hanna’s performance. Further, follow up probes demonstrate sustained progress within each problem type. See Table 4 for a list of average performance by phase and problem type.

The Tau effect size was moderate and statistically significant for all problem types (for change problems $\tau = 0.61, p < 0.01$; for group problems $\tau = 0.70, p < 0.01$; for compare problems $\tau = 0.66, p < 0.01$). In sum, visual and statistical analysis shows a clear difference in level and trend, demonstrating one basic effect.

Table 4.

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Intervention: Change</th>
<th>Intervention: Group</th>
<th>Intervention: Compare</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M (SD)$</td>
<td>$M (SD)$</td>
<td>$M (SD)$</td>
<td>$M (SD)$</td>
</tr>
<tr>
<td>Change</td>
<td>0.33 (0.57)</td>
<td>4.00 (1.41)</td>
<td>5.00 (0.00)</td>
<td></td>
</tr>
</tbody>
</table>
A visual analysis of Theo’s data shows some instances of overlapping data points in baseline with the change problem intervention phase (20% overlap). For group problems there was no instances of overlapping data points (0%) and for compare problems the first data point of five (20%) overlapped with the baseline. The visual analysis demonstrates a clear change in level and trend from baseline to intervention for each problem type. This indicates three demonstrations across all problem types. Further, continual probing demonstrated sustained progress within each problem type. For group and compare problems it was observed that there was an improvement on the final data points before those specific problem types were taught. This information can be interpreted in two ways. From a self-regulatory perspective, it demonstrates that Theo was able to apply what he had learnt to a novel problem and generalize his skills. Indicating a strength of the intervention. From a data analysis perspective, it limits our ability to conclude that there are clearly demonstrated effects within this single participant. However, intervention data demonstrates that math performance generally improved beyond those probes when the problem types were specifically addressed in intervention. See Table 5 for a list of average scores by phase.

The Tau effect size was moderate and statistically significant for all problem types (for change problems $\tau = 0.62, p < 0.01$; for group problems $\tau = 0.70, p < 0.01$; for compare problems $\tau = 0.60, p = 0.01$). In sum, visual and statistical analysis shows a clear difference in level and trend, demonstrating a second basic effect.

<table>
<thead>
<tr>
<th></th>
<th>0.00 (0.00)</th>
<th>0.00 (0.00)</th>
<th>4.67 (0.52)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compare</td>
<td>0.00 (0.00)</td>
<td>1.00 (0.00)</td>
<td>0.00 (0.00)</td>
</tr>
</tbody>
</table>

Note. Shaded boxes represent problem types that have been taught.
Table 5.

*Theo’s average level of performance on each problem type at each phase of the intervention*

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Intervention (Change)</th>
<th>Intervention (Group)</th>
<th>Intervention (Compare)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M \ (SD)$</td>
<td>$M \ (SD)$</td>
<td>$M \ (SD)$</td>
<td>$M \ (SD)$</td>
</tr>
<tr>
<td>Change</td>
<td>0.50 (0.54)</td>
<td>2.85 (1.57)</td>
<td>6.00 (0.00)</td>
<td>6.00 (0.00)</td>
</tr>
<tr>
<td>Group</td>
<td>0.83 (0.75)</td>
<td>1.67 (1.15)</td>
<td>5.20 (1.09)</td>
<td>6.00 (0.00)</td>
</tr>
<tr>
<td>Compare</td>
<td>0.17 (0.41)</td>
<td>4.00 (0.00)</td>
<td>4.60 (2.17)</td>
<td></td>
</tr>
</tbody>
</table>

*Note. Shaded boxes represent problem types that have been taught*

A visual analysis of Penelope’s data shows some instances of overlapping data points between the baseline performance and after intervention. Specifically, for change problems there was four instances (46%) of overlap between baseline and intervention sessions. For group problems there were no instances of overlapping data points. For compare problems Penelope demonstrated an improvement to 100% accuracy before that problem type was taught. Therefore, there was 100% overlap between baseline and intervention sessions. Similar to as described in Theo’s performance, this generalization of skills to novel problem types implies that Penelope gained many self-regulatory skills that she was able to apply to new math questions. However, this generalization in skills from a purely methodological perspective, limits our ability to demonstrate an effect of intervention on the increase in performance across skills. The visual analysis demonstrates a clear change in level from baseline particularly for group and compare problems, and for change problems to a lesser degree. This indicates two demonstrations across skills (group and compare) within Penelope’s performance. Further, continual probing demonstrated sustained progress within each problem type, and a generalization of skills to
untrained problem types. For example, Penelope’s performance on compare problems jumped from 1 to 6 before it was intervened on.

The Tau effect size was moderate and statistically significant for all problem types (for change problems $\tau = 0.61, p < 0.01$; for group problems $\tau = 0.70, p < 0.01$; for compare problems $\tau = 0.66, p < 0.01$). In sum, visual and statistical analysis shows a clear difference in level and trend, demonstrating a third basic effect.

Table 6.

**Penelope’s average level of performance on each problem type at each phase of the intervention**

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Intervention (Change)</th>
<th>Intervention (Group)</th>
<th>Intervention (Compare)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M (SD)$</td>
<td>$M (SD)$</td>
<td>$M (SD)$</td>
<td>$M (SD)$</td>
</tr>
<tr>
<td>Change</td>
<td>1.50 (0.93)</td>
<td>3.50 (1.65)</td>
<td>5.50 (0.71)</td>
<td>6.00 (0.00)</td>
</tr>
<tr>
<td>Group</td>
<td>0.75 (0.71)</td>
<td>1.67 (0.58)</td>
<td>5.20 (0.84)</td>
<td>6.00 (0.00)</td>
</tr>
<tr>
<td>Compare</td>
<td>1.50 (0.76)</td>
<td>1.00 (0.00)</td>
<td>6.00 (0.00)</td>
<td>5.40 (0.89)</td>
</tr>
</tbody>
</table>

*Note.* Shaded boxes represent problem types that have been taught

A visual analysis of Michael’s data shows few instances of overlapping data points between the baseline performance and after intervention. Specifically, for change problems 7% of the post intervention data points overlapped with the baseline and there were no overlapping data points for group problems. The visual analysis demonstrates a clear change in level from baseline to intervention for the two problem types that were taught. The untaught problem types did not substantially improve. This indicates two demonstrations across skills within Michaels’ performance. See Table 7. For a list of the average level of performance for each phase of the intervention. Finally, the visual analysis demonstrates a clear difference in trend in regard to the math performance.
The Tau effect size was moderate and statistically significant for both taught problem types (for change problems $\tau = 0.58, p = 0.01$; for group problems $\tau = 0.78, p < 0.01$). In sum, visual and statistical analysis shows a clear difference in level and trend, demonstrating a fourth basic effect.

Table 7.

Michaels’s average level of performance on each problem type at each phase of the intervention

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Intervention (Change)</th>
<th>Intervention (Group)</th>
<th>Intervention (Compare)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M$ (SD)</td>
<td>$M$ (SD)</td>
<td>$M$ (SD)</td>
<td>$M$ (SD)</td>
</tr>
<tr>
<td>Change</td>
<td>0.33 (0.58)</td>
<td>3.78 (1.78)</td>
<td>3.75 (0.96)</td>
<td></td>
</tr>
<tr>
<td>Group</td>
<td>0.00 (0.00)</td>
<td>0.50 (0.71)</td>
<td>4.37 (1.30)</td>
<td></td>
</tr>
<tr>
<td>Compare</td>
<td>0.00 (0.00)</td>
<td>0.00 (0.00)</td>
<td>0.00 (0.00)</td>
<td></td>
</tr>
</tbody>
</table>

Note. Shaded boxes represent problem types that have been taught.

These results indicate all participants improved their math performance throughout the intervention across taught problem types. Four basic effects were demonstrated, with clear changes in level and trend from baseline to intervention for each participant and taught problem types. Therefore, it is clear that there is a functional relation between the combined intervention and increases in mathematical performance in word problems for students in Grades 1 and 2.

Generalized math performance. To assess generalization, two subtests from the KeyMath-3 (Connolly, 2007) was conducted just prior to the first intervention session and after the intervention was completed. These subtests are applications of problem solving, and foundations of problem solving, which together make up the Applications cluster on the KeyMath-3 (Connolly, 2007). Within these two subtests two of the questions on the foundations of problem-solving subtests aligned closely with the content taught on the intervention. At the
first time point, one participant got both of these questions correct and the other got one correct. At the second time point all of the participants got these questions correct. The participant’s standard scores for the Applications cluster and the raw scores from the subtests at each time point can be found in Table 8. Although performance at the two time points varied for each participant, overall the participants all demonstrated gains in at least one subtest. Two of the participants' (Hanna and Penelope) scores stayed the same or declined on the applications of problem-solving subtest. The content on the foundations of problem-solving subtest more closely aligned with the skills intervened on throughout the sessions. When examining the raw scores, it is evident that all four participants demonstrated an increase in their raw scores on the foundations of problem-solving subtests, which more closely aligned with the intervention’s teaching. It is due to their age change before and after the intervention that not all of their standard scores demonstrated an increase. Finally, some evidence for generalization can be seen in student performance on untaught problem types. Specifically, Theo, Penelope, and Michael demonstrated gains on untaught problem types, indicating that they were able to independently apply skills that they were taught to dissimilar problems in the intervention.

Table 8.

*Student’s Scores on the KeyMath-3 Before and After Intervention*

<table>
<thead>
<tr>
<th></th>
<th>Applications (SS)</th>
<th>Foundations of Problem Solving (Raw Score)</th>
<th>Applied Problem Solving (Raw Score)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hanna</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T1</td>
<td>83</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>T2</td>
<td>84</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>Change</td>
<td>+1</td>
<td>+2</td>
<td>0</td>
</tr>
<tr>
<td>Theo</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T1</td>
<td>85</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>T2</td>
<td>112</td>
<td>9</td>
<td>12</td>
</tr>
<tr>
<td>Change</td>
<td>+27</td>
<td>+5</td>
<td>+4</td>
</tr>
<tr>
<td>Penelope</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T2</td>
<td>84</td>
<td>11</td>
<td>5</td>
</tr>
<tr>
<td>Change</td>
<td>-7</td>
<td>+5</td>
<td>-2</td>
</tr>
</tbody>
</table>
Math Anxiety

To assess the intervention’s impact on math anxiety, self-reported levels of math anxiety were measured and closely monitored throughout the study. Students’ ratings of math-anxiety are presented in Figure 2.
Figure 2. Student’s math-anxiety across baseline and intervention
A visual analysis of Hanna’s data shows one instance (5%) of overlapping data points between baseline performance and the intervention phases. The analysis shows a clear and immediate change in both the level ($M = 13.33$ in baseline, $M = 1$ throughout intervention) and trend of Hanna’s ratings of math anxiety. The Tau effect size for Hanna’s symptoms of math anxiety was moderate and statistically significant ($\tau = -0.61, p < 0.01$). Overall, visual and statistical analysis shows that a clear difference in level and trend demonstrating one basic effect.

A visual analysis of Theo’s data shows Theo’s self-report ratings of math anxiety demonstrated a decline during the baseline portion of the study. Therefore, it cannot be concluded that the intervention itself is what caused his decline in self-reported ratings of math anxiety, and perhaps it was merely exposure to math. Further, Theo’s responses showed some instances (13%) of overlapping data points between the baseline performance and throughout the intervention. The analysis also shows a clear change in level ($M = 3$ in baseline, $M = 1$ throughout intervention) on Theo’s ratings of math anxiety. The Tau effect size for Theo’s symptoms math anxiety was moderate and statistically significant ($\tau = -0.61, p < 0.01$) Overall, visual and statistical analysis shows that a clear difference in level and trend, but the improving baseline precludes an inference of a second basic effect.

A visual analysis of Penelope’s data shows variability. Further, it demonstrated many instances of overlapping data points between the baseline performance and after intervention. Further, the analysis does not show a clear change in level ($M = 9$ in baseline, $M = 10$ throughout intervention). The Tau effect size for Penelope’s symptoms of math anxiety was weak and statistically insignificant ($\tau = 0.04, p < 0.83$).

A visual analysis of Michael’s data shows many instances (72%) of overlapping data points between the baseline performance and throughout the intervention. Michael’s
performance showed a delayed change in trend, which resulted in many overlapping data points before the change initiated. The analysis also shows a gradual change in level ($M = 26$ in baseline, $M = 21$ throughout intervention) on Michaels ratings of math anxiety. In the case of both problem types, it took 7 intervention sessions after switching problem types before a marked decrease in level and decreasing trend was observed in his levels of math anxiety. Due to Michael’s routine absences, and delayed start to intervention, time was limited to observe the pattern of his math anxiety behaviour as time continued, but improvements were gradually noted. Specifically, if we look at the mean levels of self-report math anxiety for the last three data points of each phase the means are $M = 26$ during baseline, $M = 17$ for phase 1, and $M = 11$ for phase 2. These results indicate that there is a delayed change in level and trend. The Tau effect size for Michael’s symptoms of math anxiety was weak and statistically insignificant ($\tau = 0.08, p = 0.66$). Overall, Michael’s levels of math anxiety represent a compromised demonstration of a basic effect, due to the delay before a change was observed.

These results indicate some participants improved their feelings of math anxiety throughout the intervention. With one basic effect, and a second compromise basic effect demonstrated, and the effects themselves inconsistent across students, a functional relation between the combined intervention and decreases in self-report math anxiety in word for students in Grades 1 and 2 was not demonstrated.

**Math Motivation and Self-Regulation**

The assess the intervention’s impact on the student’s math motivation, math value, math self-efficacy, and self-regulation the researcher-adapted MSLQ (McKeachie, Pintrich, & Lin, 1985) was used. The participants average scores on the 7-point Likert scale for each area at baseline (MT1) and after intervention (MT2) and the difference between their two scores can be
found in Table 9. Overall the participants demonstrated gains across self-regulation and decreases in math specific test-anxiety throughout the intervention.

On the MSLQ, goal orientation is defined as the participant’s perceptions of why they are engaging in learning math. Intrinsic goal orientation measured the participant’s engagement in learning math due to reasons such as curiosity, challenge, or a desire to reach mastery. Overall, the participants showed slight gains in this area, with all participant’s average scores for this scale being a six out of seven or higher. Extrinsic goal orientation measured the participant’s engagement with learning for reasons such as the evaluation of others, competition or good grades. Of all the facets of motivation measured, this was the participants’ overall area of largest gain, with 3 of the participants’ averages placing over 1 full point higher after intervention. Task value refers to the value the student places on math. Specifically, it assesses how important, how interesting, and how useful math is. Overall, participants showed slight gains in this area, with an average increase of 0.88 after the intervention. Control of learning measured the participant’s beliefs that their efforts to learn math will result in positive outcomes. Three participants showed no change at all in this area after the intervention and one showed a slight decrease ($M = -0.25$). In sum, with regard to goal orientation, the largest gains were demonstrated in extrinsic goal orientation, and some gains were demonstrated with regard to intrinsic goal orientation and task value.

The self-efficacy for learning and performance scale measured the student’s expectancy to succeed on math tasks, and their appraisal of their confidence to succeed at math. Overall, participants gained an average of 0.85 in this area after the math task. Within this area Michael, demonstrated the largest gain observed on the questionnaire, with a change of 2.27 after the intervention.
Finally, the Motivation scale included math specific test anxiety, this measured feelings of worry and affective components of worry felt by students during math tests. Overall participants demonstrated an average change of -1.20 on math specific test anxiety after the intervention, with all but Penelope showing decreases in their ratings. This parallels the session by session ratings, with Hanna demonstrating the largest decrease in ratings of math anxiety on the MSLQ (a decrease of 3.80 points on a seven-point scale) and her demonstration of a basic effect. Further, Michael whose session ratings demonstrated a compromised basic effect, demonstrated a decrease in levels of math anxiety as rated on the MSLQ of 1.60.

In addition to the Motivation scale the Metacognitive Self-Regulation subscale was used. This subscale measured the planning, monitoring, and regulating abilities of the participants before and after the intervention. Overall, the participants demonstrated an average gain of 1.10 after the intervention, with all but Penelope showing gains in this area.

Table 9.

| Student Scores from Select Scales on the Motivational Scales for Learning Questionnaire |
|-----------------------------------------------|---------------|----------------|----------------|----------------|----------------|----------------|----------------|
| Intrinsic Goal Orientation^a                  | Extrinsic Goal Orientation^a | Math Value^a | Control of Learning Beliefs^a | Math Self-efficacy for Learning and Performance^a | Math Specific Test Anxiety^a | Metacognitive Self-regulation |
| MTI                                           | 6.50          | 6.00          | 5.17           | 4.00           | 6.12           | 6.60           | 3.60           |
| MT2                                           | 6.00          | 6.00          | 6.00           | 4.00           | 6.00           | 2.80           | 6              |
| \( \Delta \)                                  | -0.50         | 0.00          | +0.83          | 0.00           | -0.12          | -3.80          | +2.40          |
| MTI                                           | 4.00          | 3.75          | 3.50           | 4.50           | 5.00           | 4.00           | 3.80           |
| MT2                                           | 6.00          | 5.00          | 5.33           | 4.50           | 5.00           | 4.00           | 5.4            |
| \( \Delta \)                                  | +2.00         | +1.25         | +1.83          | 0.00           | +0.50          | -0.60          | +1.60          |
| MTI                                           | 5.00          | 4.50          | 5.67           | 4.50           | 5.87           | 3.40           | 4.40           |
| MT2                                           | 6.50          | 5.75          | 4.33           | 4.50           | 6.62           | 4.60           | 4.20           |

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Social Validity

At the end of the intervention a social validity questionnaire was given to the participants and their teacher to assess the opinions of the participants themselves, and their teacher who worked with them daily. Students’ perceptions of the efficacy of the intervention are displayed in Table 10, and their teacher’s perceptions in Table 11.

Table 10.

Student’s Perceptions of The Efficacy of The Intervention

<table>
<thead>
<tr>
<th></th>
<th>Hanna</th>
<th>Theo</th>
<th>Penelope</th>
<th>Michael</th>
<th>Mean score out of a maximum 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working on math together helped me get better at doing word problems</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>5</td>
<td>4.25</td>
</tr>
<tr>
<td>Working on math together helped me get better at math in class</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>5</td>
<td>3.25</td>
</tr>
<tr>
<td>Working on math together helped me feel more confident about math</td>
<td>5</td>
<td>3</td>
<td>1</td>
<td>5</td>
<td>3.5</td>
</tr>
<tr>
<td>Working on math helped me feel less worried about math</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>5</td>
<td>2</td>
</tr>
</tbody>
</table>

The results indicate that three of the students responded favourably in perceiving the intervention to have helped them perform better on math word problems, and one responded neutrally (M = 4.25). Additionally, two students indicated that they found that the intervention helped them to perform better at math outside of the intervention and with their confidence in math, with two students responding neutrally or negatively. The majority of participants
indicated that they did not feel the intervention helped them to feel less worried about math (M score = 2).

Table 11.

**Teacher Perceptions of The Efficacy of The Intervention**

<table>
<thead>
<tr>
<th></th>
<th>Hanna</th>
<th>Theo</th>
<th>Penelope</th>
<th>Michael</th>
<th>Mean score out of a maximum 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>I noticed a difference in the participant’s math word problem performance</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>3.25</td>
</tr>
<tr>
<td>I noticed a difference in the participant’s math performance in class</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>3</td>
<td>3.75</td>
</tr>
<tr>
<td>I noticed a difference towards the participant’s negative feelings towards math</td>
<td>1</td>
<td>blank</td>
<td>1</td>
<td>2</td>
<td>1.3</td>
</tr>
</tbody>
</table>

The teacher’s ratings on the validity questionnaire were completed before she met with the researcher where the results of the study were discussed, and the student’s improvements demonstrated. The results of the teacher’s social validity questionnaire indicate that generally ambivalent with regard to improvement in the participant’s math performance across students (M score = 3.25), and the participants performance specifically on math word problems (M score = 3.75). shown the graphs and scores indicating the improvements seen in intervention. Consistent with the students, the teacher indicated that she did not notice a difference regarding the participants’ feelings towards math (M score = 1.3). It is important to note that she did not answer this question for one participant as she did not feel they had negative feelings towards math prior to or after the intervention. In the teacher’s comments about the intervention she stated “The intervention has been great! Nathalie, you fit right into the classroom environment. The student who I think has made the most growth is Penelope. Regular attendance has been a struggle for Hanna and Michael. However, when Michael and Hanna were present they both were very excited to go with Nathalie to do math!”.
Student Summaries

To provide insight and a contextual framework for the results of this study, a summary of each participant, their personal characteristics, and their individual experience is provided below.

**Hanna.** Hanna was a student who was shy upon meeting the interventionist. It became evident very quickly that she struggled with several math concepts. Similarly, at the beginning of the intervention Hanna self-reported very high levels of math anxiety. Although Hanna indicated these ratings on the ‘End of Today’s Session questionnaire’, her symptoms of anxiety were not directly observable within intervention sessions. Throughout the sessions Hanna demonstrated gains in math performance and decreases in math anxiety. Hanna demonstrated some ownership over her own learning through coining terms such as “the Hanna way” when computing answers to math word problems. On one occasion through the intervention Hanne demonstrated a spike in her symptoms of math anxiety. In communicating with Hanna, she reported that she was having a bad day that day and that’s why she was feeling bad. Overall Hanna demonstrated gains in math performance, math self-confidence and reductions in math anxiety that suggest that overall, she benefited from participation in the intervention.

**Theo.** Theo was one of the participants who entered the intervention with many basic math skills intact. Theo was a participant who was an English language learner and who experienced great difficulties with reading. Compared to his reading abilities, math was an area of strength for him. As such, Theo generally approached math problem solving with confidence. As the intervention continued, Theo demonstrated increases in his confidence and ease when solving math problems, as evidenced in his increased math performance and his reduction in symptoms of math anxiety, although his symptoms of math anxiety were quite low to begin with. Theo demonstrated an increase in his abilities to reflect on intervention sessions and apply what
he had learnt to future sessions. For example, for the first several intervention sessions on the structured reflection, Theo answered most questions “I don’t know”, but as the intervention went on Theo continued to engage more with this portion of the intervention. Specifically, on the twelfth intervention session, when asked what he did during that session that was successful Theo responded, “I problem solved when my first guess was wrong.” Overall, Theo’s increased reflection, math performance, and decrease in his symptoms of math anxiety suggest that he also did benefit from his engagement in the intervention.

**Penelope.** Throughout the intervention Penelope was resistant to engage in the intervention. Penelope often did not want to come to intervention sessions and she demonstrated several avoidance behaviours. For example, in five of the intervention sessions Penelope refused to speak and insisted on only writing what she wanted to say. Although Penelope was one of the participants who entered the interventions with a greater number of basic math skills, she demonstrated large amounts of variability on measures of both math anxiety and math performance. It was observed throughout the intervention that Penelope’s mood upon entering the intervention greatly impacted her willingness to engage in the session and her performance throughout the session. For example, one day Penelope participated in the intervention after recess, during which she reported that she got in a fight with one of her friends and that she was in a very bad mood. Throughout this session Penelope rated higher than usual levels of math anxiety and lower than usual math performance.

Despite Penelope’s variable performance within the intervention, the classroom teacher rated her as experiencing the largest improvements of the participants in this study. It is possible that because of Penelope’s greater math skills upon beginning the intervention, her teacher was better able to see her gains in the math classroom, when compared to students like Hanna or
Michael. Overall Penelope’s math performance did improve both on the targeted skills and as observed by the teacher, but her symptoms of math anxiety and feelings of math self-confidence were much more variable.

**Michael.** Michael’s teacher reported that she was hesitant to refer him for the intervention due to ongoing behavioural concerns in the classroom. Michael was a student who was typically in the halls during instructional periods or having a behavioural outburst in the classroom. He began the intervention with very few basic math skills and very poor basic reading skills. Throughout the first few intervention sessions many behavioural management strategies were required to support Michael’s engagement in solving math problems. Michael often yelled “no!” or pretended to be asleep when initially presented with math problems. Throughout the screening and baseline data collection it was not uncommon for him to hide under tables, leave the room, or cry. When prompted to answer math questions during the baseline phase Michael would either leave question blank or answer with a haphazard answer (for example, answering a question where the correct answer was “5” with “310,000,000,000,000”). As the intervention progressed, Michael continued to demonstrate some avoidance behaviours, often drawing funny and elaborate designs within the schemas while computing the answer. At the end of the intervention, Michael continued to draw his schemas creatively, for example drawing stars instead of circles, but his work was much cleaner and resulted in the correct answer. Paralleling this, throughout the intervention Michael demonstrated a gradual increase in math problem solving performance and a gradual decrease in his symptoms of math anxiety. Nearing the end of the intervention, Michael appeared to enjoy the intervention sessions. Specifically, he no longer protested in participating in the intervention, and often requested if he could go first. Michaeals shift in behaviour illustrates the importance of not only the intervention, but also in
having a positive interventionist-student relationship, particularly with students who likely
generally receive primarily negative adult attention throughout the day due to problem
behaviours. Although I was unable to work through all of the problem types with Michael, he is
the participant who I believe benefited the most from the intervention.
Chapter V: Discussion

The purpose of the present study was to investigate a pilot series of lessons incorporating self-regulated learning and schema-based math instruction amongst early elementary grade students. It was hypothesized that the intervention would decrease self-reported levels of math anxiety and improve math performance. The following section will discuss the major findings, limitations, implications, and future recommendations for future research.

Major Findings

The visual and statistical analyses of the data demonstrate that the combined intervention was an effective method of improving math word problem performance in students in grades one and two. Math word problem performance improved across all participants and problem types, demonstrating a functional relation between the combined intervention and math word problem performance in grade one and two students. For Theo, Penelope, and Michael there was some behavioural covariation and carryover across problem types, meaning that their performance on math problems improved before those specific problems were taught. Although this limits the number of demonstrated effects observed within participants, it suggests an increase in math self-confidence and self-regulatory abilities, as the students were able to independently apply previously learnt information to help solve novel problems. Further, these improvements were seen more generally in increase in raw scores for all participants on the subtest corresponding most closely with taught skills.

Visual and statistical analyses of the self-report ratings of math anxiety demonstrate variable findings. One participant, Hanna, demonstrated a clear change in level and trend in her levels of math anxiety. This change in symptoms of math anxiety were further demonstrated in her ratings on the MSLQ math test anxiety subtest. For Michael, a compromised basic effect was
demonstrated, as he showed significant decreases in his levels of math anxiety, but these decreases were quite delayed. Michael’s symptoms of math anxiety were also found to be lower on the MSLQ math test anxiety subtest. Theo and Penelope demonstrated variable levels of math anxiety. Therefore, a functional relation was not demonstrated between the combined intervention and self-report levels of math anxiety performance in grade one and two.

On the pre and post measures of student motivation, self-regulation, and math specific test anxiety demonstrated some gains after the intervention. Specifically, the largest overall gains were observed in extrinsic goal orientation and self-regulation. Although that these gains must be interpreted with caution due to the small sample size, these findings are consistent with Ramirez, Shaw, and Maloney (2018) proposal that students play an active role in creating meaning in their mathematical educational experiences and that their internal narrative impacts their symptoms of math anxiety.

**Social Validity.** Three of the four participants indicated that they felt that the intervention helped them get better at math word problems and two reported positively that the intervention helped them in math class and with their math self-confidence. The results of the teacher’s social validity questionnaire indicate that she generally felt ambivalent with regard to improvement in the participant’s math performance across students, with the exception of Penelope, the participant who started the intervention with the most skills. Participants and the teacher did not notice a difference in the participant’s feelings of math anxiety, or negative feelings towards math. As students were more engaged with their monitoring of their progress of math performance, not math anxiety it is possible that this had an impact on the discrepancy in the social validity ratings.
When further probed, the teacher reported that she did feel the intervention was helpful to some degree, but that the confinements of working within a school and the inconsistent attendance of some students impacted the overall efficacy of some students. The teacher reported feeling that the intervention was most helpful for Penelope’s math performance and reported observing a general improvement in Theo’s math performance in class. These students entered the intervention with more math skills than Hanna or Michael. Therefore, it is possible that despite improvements observed in intervention for Hanna and Michael, that their low starting point meant that despite gains their overall math performance continued to be below what was expected in their class, resulting in a lack of observed improvements. Further, it is possible that due to the specificity of the nature of the skills that were addressed in the intervention, there may not have been many opportunities for the students to demonstrate their learned skills in class for the teacher to see.

**Limitations**

There are several possible limitations which may have impacted the results of the study. These limitations include the nature and design of the study, the combined nature of the intervention itself, and some of the measures used throughout the intervention.

The nature and design of the study presents itself as a limitation, as there was a small sample size (four). All four of the participants were from one classroom within a school with considerable socio-economic diversity. Although these commonalities reduce possible threats to internal validity, it may reduce the generalizability of these findings to varied contexts. As previously mentioned, the school that the students attended participated in a school wide self-regulatory intervention, Zones of Regulation (Kuypers, 2011) prior to the present intervention. It is possible that this previous instruction around identifying and regulating emotions had an
influence on the students’ response to the present intervention. Although Zones of Regulation has not been shown to have a clinically significant impact on student’s self-regulatory abilities (Valkanos et al., 2016), it may have provided some introductory knowledge to prime the students to better respond to the present intervention.

It is important to highlight that two of the participants demonstrated considerable difficulty with regards to reading on the screening measures. As the questions were read aloud for all participants, it was determined that including these students with reading difficulty in the intervention would not greatly alter the procedures. However, it is important to note that these student’s history of difficulty with math word problems may have been impacted by their lack of basic reading skills and their symptoms of math, or general academic anxiety. Finally, the student’s reading difficulties are important to note as their reliance on the questions being read to them may have increased the demands on their working memory.

Research suggested that one’s working memory has a limited and finite capacity (Cowan, 2010) and that one’s working memory is impaired by symptoms of math anxiety (Ashcraft & Kirk, 2001; Ashcraft & Moore, 2009; Engle, 2002; Young, Wu & Menon, 2012). It is well evidenced that working memory plays a vital role in both math computation (Ashcraft & Krause, 2007) and self-regulation (Musso, Boekaerts, Segers & Cascallar, 2019). Therefore, the students’ potentially impaired capacity of their working memory may have been a contributor to challenges with math performance and symptoms of math anxiety. These effects were attempted to be curtailed by incorporating accommodations and intervention components such as chunked, short, simple, and repeated verbal instructions and providing visual prompts. However, the potential additional tax on the working memory of Theo and Michael, as they were unable to
independently reread the math word problems, may have impaired their response to the intervention. Further, working within the bounds of a school and its schedule presents itself as a limitation. As the school year came to an end the researcher was unable to administer the intervention for the final problem type for the fourth participant (Michael) or conduct long-term follow ups on the participants. Without long-term follow ups one cannot conclude if the positive impact of the intervention resulting in a lasting change in the student’s math word problem performance and attitude towards math.

Additionally, the intervention combined several different components, so the effects of specific components cannot be isolated. As the intervention targeted several aspects of self-regulation one is unable to conclude which specific factors of self-regulation were the most beneficial or whether all were necessary in order for the intervention to have a positive effect. Anecdotally, it appeared that three students benefited from and were fully engaged in the reflection portion of the intervention, with some participants reporting insightful comments and connections between the work done in that session and previous sessions. Contrarily, one participant (Penelope) consistently did not engage in the reflection period, despite prompting. This likely impacted her engagement with self-regulation and may be an explanation of her varied self-reports of math anxiety.

Within the small sample, two of the participants demonstrated variability within their ratings of math anxiety impacted the conclusions that could be made. As the participants were regularly exposed to math word problems throughout the intervention, one is unable to conclude if exposure simply was sufficient to reduce some symptoms of math anxiety. Further, is worth noting that self-report measures of math in young children appeared to be
strongly influenced by situational factors, such as their mood or events that occurred in the classroom that day. Specifically, it was observed within many participants that if they rated that they were in a bad mood prior to the intervention session, they then also rated high levels of math anxiety at the end of the session.

Finally, many of the measures, although originally validated and found to be reliable, were adapted by the researcher to be appropriate for younger students. Additionally, the word problems used for progress monitoring were researcher generated. This was necessary as few measures exist that were individualized to the student’s preferences and included their names and the names of their friends. The researcher attempted to make the problems equivalent by using randomly generated numbers under 20 and basing question types and wording off existing word problems, but the probes were not field tested before use in the intervention to confirm their equivalence.

**Implications**

The gains in math word problem performance suggest that the combined intervention is a useful tool in increasing math performance in young learners. Further, the demonstrated gains in self-regulation observed on the MSLQ reinforce previous research that simply by exposing students to features of strategic content learning and reflection can generally lead to some improvements in their self-regulation. Anecdotally, it was observed that students demonstrated increased engagement and excitement when math word problems included the names of them and their friends. This presents itself as a simple tool that future work can use to increase student engagement.

Although the results with regard to the intervention’s impact on math anxiety were inconclusive, the results still have several important implications for the field of educational
psychology. Firstly, although the results were mixed, the intervention was found to be effective in reducing anxiety in the two students with the most severely rated symptoms of math anxiety. This suggests that the intervention may be more effective on students with consistent and high levels of math anxiety. Additionally, the present study contributes to existing literature on math anxiety which could allow for a future meta-analysis to disentangle the complicated effects of self-regulation, math performance, and math anxiety. Further, the present study piloted forth a preliminary modification of a measure which can be expanded upon to broaden and improve future research on math anxiety. Thus, it took the crucial first steps in generating a math anxiety scale that correctly measures it as a state anxiety, rather than a trait.

Recommendations for future research

This pilot study demonstrated that incorporating features that target self-regulation may a useful mechanism when incorporated into math interventions. Therefore, future research should continue to investigate components of self-regulation as an important component to math instruction. Future research should compare the efficacy of a self-regulatory intervention, direct instruction intervention, and a combined intervention in order to isolate which facet provides the greatest benefit for the participants.

As it was observed that many of the participants enjoyed and engaged in the reflection portion of the intervention future research should further investigate reflection as a tool in math education. Ramirez, Shaw, and Maloney (2018) that student’s feelings of math anxiety are determined but how they interpret and appraise previous math experiences and outcomes, rather than the outcomes themselves. Based off this model, the reflection component of future interventions could encourage students to re-appraise negative math events in a more positive manner.
Future research should continue to try to improve the validity of measures of math anxiety, particularly with young children. There issues regarding current measures of math anxiety in young children are twofold. Firstly, young students’ ratings of math anxiety were often influenced by external factors. Additionally, as previously mentioned, many measures of math anxiety incorrectly measure math anxiety as a state anxiety, rather than a trait. Research has demonstrated that physiological are effective means to assess children’s symptoms of math anxiety. For example, Hunt, Bhardwa, and Sheffield (2017) used heart rate, systolic blood pressure, and diastolic blood pressure in order to measure children’s symptoms of math anxiety. In this study they found that heart rate and blood pressure increased as a function of math problem difficulty within a sample of 77 nine to eleven-year-old students. Integrating these measures in an intervention study may assist in accurately measuring student’s symptoms of math anxiety.

Another method of potentially improving self-report measures of math anxiety and increasing explicit reflection on symptoms of math anxiety is incorporating a psychoeducational component prior to the intervention. Assisting children to label their emotions and feelings and differentiate between different states or feelings may help students to better label and rate their experiences and in turn reduce the variability in their self-report measures. For example, Coping Cat is an evidence based and effective intervention designed to reduce symptoms of general anxiety in young children. Coping Cat focuses on psychoeducation first, such as recognition of signs of anxious arousal, and then shifts to exposure to anxiety inducing situations (Podell, Mychailyszyn, Edmunds, Puelo, & Kendall, 2010). Additionally, as this intervention demonstrated inconclusive results with regard to the intervention’s impact on math anxiety it is possible that the intervention was missing a crucial component to address the anxiety.
Echoing this, McDonough and Ramierz (2018) found that students who are vulnerable to feelings of math anxiety are vulnerable to forgetting recent learning of math. Specifically, they propose that the sense of threat leads student to process information in a superficial manner and poor memory performance. This model suggests the importance on intervening on anxiety first, before expecting students to engage in math learning. Turning again to evidence based and effective existing interventions for treating general anxiety in children, one could incorporate specific features to treat symptoms of anxiety. For example, incorporating the explicit teaching of relaxation techniques through video modeling and role plays from the Coping Cat program (Podell, Mychailyszyn, Edmunds, Puelo, & Kendall, 2010). Supporting this suggestion, LaGue, Eakin, and Dykeman (2019) successfully implemented a mindfulness-based cognitive therapy to reduce symptoms of math anxiety in adolescents in a single case design.

Finally, future research should continue to develop and validate a measure of math anxiety in which the wording of items correctly measures symptom as a state anxiety. The fundamental difference between math anxiety and general anxiety is that math anxiety is a form of state (momentary) anxiety occurring when exposed to a mathematical stimulus, whereas general anxiety is an experience of trait (habitual) anxiety (Biggs, Pres, 2001). State and trait forms of anxiety are fundamentally different; it has been found that self-report measures of trait and state anxiety often lead to very different results (Aiken, 1970). Thus, the dearth of state-based measures of math anxiety presents itself as a crucial barrier in generating effective and pragmatic interventions for math anxiety. The present study attempted to address this issue in adapting an existing questionnaire to pose questions in order to address the participant’s state feelings of anxiety during the mathematical task that just occurred. Future research should expand on this to develop and validate a formal measure to do this. Correctly measuring math
anxiety as a state will increase the ecological validity of research pertaining to math anxiety making future research more valid and appropriate for generating interventions.

**Recommendations for future implementations of this or similar interventions.** This study piloted the use of a novel intervention to address math performance and math anxiety in grade one and two students. Upon reflection, after the implementation of this intervention, there are several components that should be considered before this intervention, or a similar one, is implanted. Firstly, although equivalency within the math word problems was attempted, field testing prior to the intervention would allow the researchers to be sure that the word problems are truly equivalent. Secondly, to assist the selection of appropriate participants, one could consider screening an entire class on their math word problem solving ability and symptoms of math anxiety. Using these data, the researchers could select the participants who meet both of these criteria. This may result in receiving participants more similar to Hanna and Michael, who demonstrated the lowest initial math performance and the highest ratings of math anxiety.

Although the intervention was associated with gains in math word problem performance, the integration of math fluency drills, such as flash cards, strategic counting techniques, or the use of visuals or objects may have increased the rate of improvement throughout the intervention. As the intervention went on, many of the continual mistakes made by students throughout the intervention were simple errors due to mistakes when counting to find the answers, rather than errors in creating a number sentence from the word problem. Had the intervention included math fluency drills, the student’s may have engaged in less math calculation errors and increased math word problem performance. For example, incorporating features from Math Flash or Pirate math, such as a flash card warm up (Fuchs, Fuchs, Powell, Seethaler, Carino & Fetcher, 2008) may result in less calculation errors. These intervention
programs have been studied and found to be effective in increasing math performance in students with a specific learning disability in math. Future implementations of similar interventions should investigate integrating this into interventions in addition to self-regulation in attempts to address math performance and math anxiety in students with early math difficulties.

In the present intervention, students engaged in self-assessment and revision of their work throughout the problem solving and strategy use at the end of each session. This monitoring and tracking of math performance within each session may have been one of the reasons that a positive effect observed. Contrarily, although students self-reported their symptoms of math anxiety, their feelings were not assessed or reflected on. It is possible that this is one facet of the discrepant effects of the intervention. Future implementations of this or similar interventions, should incorporate targeted reflection and evaluation of symptoms of math anxiety to help students to identify and manage their potential feelings of math anxiety.

Similarly, broadening the scope of the student’s involvement in their progress monitoring may lead to greater gains in their self-regulatory abilities. Specifically, having the students be involved in the graphing of their progress monitoring data would allow them to visually see a representation of their growth in math performance, and decreases in math anxiety.

Finally, upon further reflection and guidance from my committee members, it became evident that some components of the intervention may have been fostering contradictory results. Specifically, on the ‘End of Today’s session questionnaire students were asked to rate how good they felt at math compared to their peers. This peer comparison was used to assess student levels of math self-confidence but is actually opposing some of the principles of self-regulated learning. Research in the field of self-regulated learning suggests that a best practice in providing student feedback is having the student compare their performance to a personal goal that they are
working towards, or to their past performance, rather than to their peers (Nicol & Macfarlane-Dick, 2006). In continuously having the students reflect on how they compare to their peers, it is possible that this reminded them of the discrepancy in their math ability compared to their peers and created increases in their symptoms of math anxiety. This potentially could have reduced the efficacy of the intervention and been the root of some of the variable results. Having students set a personalized goal and have them more involved in their progress monitoring would have allowed the participants to be better able to compare their present performance to their past performance, rather than their peers. This small change would allow future research to assess changes in student’s perceptions of their own abilities without contradicting self-regulated learning and possibly confounding the impact of the intervention.

Conclusions

Despite the named limitations, the findings of the present study indicate observable gains in math word problem performance when the combined intervention was employed with grade one and two students. The students demonstrated an increased ability to solve math word problems and engage in strategy use in solving said math problems. Further, it was found that student’s self-regulation and math motivation was increased to some degree. Overall, this research generally supports the inclusion of instruction specific to self-regulatory skills within math instruction.

Consistent with the past 60 years of challenges effectively reducing math anxiety (Dowker, Sarakr, & Looi, 2016) this research found inconclusive results. The combined intervention lead to a substantial decrease in math anxiety in one student, a delayed decrease in math anxiety in another, and inconsistent reports of math anxiety in the other two participates. I argue that one reason research has struggled in this area is the way in which math anxiety is
currently measured. This study attempted to address this by modifying an existing measure to better align with definitions of math anxiety. Future research should continue to try to address this and increase the ecological validity of measures of math anxiety.
References


doi:10.1016/j.beth.2010.08.006


### Before Today’s Session

Right now what kind of mood are you in?

<table>
<thead>
<tr>
<th>Good Mood</th>
<th>Bad Mood</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Good Mood Emoji]</td>
<td>![Bad Mood Emoji]</td>
</tr>
</tbody>
</table>

How motivated are you to do math today?

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Very</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>50%</td>
</tr>
<tr>
<td>100%</td>
<td></td>
</tr>
</tbody>
</table>

At the moment I’m:

<table>
<thead>
<tr>
<th>Awake</th>
<th>Tired</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Awake Emoji]</td>
<td>![Tired Emoji]</td>
</tr>
</tbody>
</table>
Appendix B

Participant Number: ______________
Session Number: ______________
Date: ______________

Looking Back on Today’s Session

While working on math today I felt:

<table>
<thead>
<tr>
<th>Bad</th>
<th>Good</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Sad Face]</td>
<td>![Happy Face]</td>
</tr>
</tbody>
</table>

Worried (Sad Face) | Calm (Happy Face)

How good are you at math?

<table>
<thead>
<tr>
<th>Worse than my friends</th>
<th>About the same</th>
<th>Better than my friends</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>Kind of</td>
<td>Not Really</td>
</tr>
<tr>
<td>Doing math today gave me a stomach ache</td>
<td></td>
<td></td>
</tr>
<tr>
<td>When it was time for math my head hurt</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I like doing a math problem like this: 124+329</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I got nervous about making a mistake in math today</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I was scared working on math today</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I got worried before I answered the math questions by myself</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I got nervous when you were about to teach something new in math</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I got worried when I didn’t understand something when doing math</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I felt nervous when I was doing math</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Administered Orally:

Now I’m going to ask you some questions about the math we did together today. The first few questions you can answer with just a yes or a no.

<table>
<thead>
<tr>
<th></th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Today I tried really hard on the math work</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I didn’t let myself get distracted while working on math</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I thought about if the answer made sense</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I thought about if there are different ways to find the answer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>What did you do while doing math today that was successful?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>What strategies have you used before that could have helped you?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>What are you going to do next time you have a question like that?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Math gives me a stomach ache
When it is time for math my head hurts
When it is time for math my heart beats fast
Figuring out if I have enough money to buy cookies and a drink is fun
I like doing math problems on the board in front of the class
I like to raise my hand in math class
I like doing a math problem like this: 124+329
I like being called on in math class
I get nervous about making a mistake in math
When the teacher calls on me to tell my answer to the class, I get nervous
I am scared in math class
Getting out my math book makes me nervous
I get worried before I take a math test
My heart starts to beat fast if I have to do math in my head
I get nervous when my teacher is about to teach something new in math
I get worried when I don’t understand something in math
I feel nervous when I am doing math
Appendix D

(Participants were given the Likert scale as a visual, but the questions were read aloud to them)

1. _____ In math class, I like when the questions are hard so I can learn new things.
2. _____ If I study right, then I will be able to learn math
3. _____ When I take a test I think about how bad I am doing compared with other students.
4. _____ I think I will be able to use what I learn in math in other subjects
5. _____ I believe I will receive an excellent grade in this math
6. _____ I am sure I can understand the most difficult part of my math class
7. _____ Getting a good grade in this math will make me feel good
8. _____ When I take a math test I think about questions on the other parts I can't answer.
9. _____ It is my own fault if I don't learn the stuff in math class
10. _____ It is important for me to learn math
11. _____ I really want to get a good grade in math
12. _____ I am sure I can learn counting and adding numbers up to 10
13. _____ If I can, I want to get better grades in math than most of the other students.
14. _____ When I have a math quiz I think about what would happen if I fail
15. _____ I am sure I can understand the hardest stuff in our math class
16. _____ I like when math is interesting even if it is difficult to learn.
17. _____ I am very interested in math
18. _____ If I try hard enough, then I will understand all of the math
19. _____ I have an uneasy, upset feeling when I have a math test
20. _____ I am sure I can do an excellent job on all my math work
21. _____ I think I will do well in Math
22. _____ I think math is helpful for me to learn
23. _____ If I don't understand math it is because I didn't try hard enough.
24. _____ I like math.
25. _____ Understanding math is very important to me
26. _____ I feel my heart beating fast when I have a math test
27. _____ I am sure I can master all the math skills I am learning in school.
28. _____ I want to do well in math because to show my family and friends I can do it
29. _____ I think I can do well in math
30. _____ During math I usually miss important parts of the lesson because I'm thinking of other things. (REVERSED)
31. _____ When I become confused about something in math I stop and try to figure it out.
32. _____ If a math question becomes hard to understand, I try to think of other ways to think about it.
33. _____ I ask myself questions to make sure I understand math
34. _____ I often find that I have trying to do a math question but don't know what I am doing (REVERSED)
<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not at all true</td>
<td>Not True</td>
<td>Not Really True</td>
<td>Not True but Not False</td>
<td>Kind of True</td>
<td>True</td>
<td>Very True</td>
</tr>
</tbody>
</table>
Sample Lesson Plan

1. **Before Today’s Session Questionnaire (2 minutes)**

**Goals:** Check in to gain an understanding of the child’s readiness to learn that day

**Prompts and Queries:** “Go ahead, there are no right or wrong answers”

**Sample Script:**

- Greet child. Typically: “Nice to see you again ____, we are going to be working on some more math today. Before we get started we are going to answer some questions”

- “Right now, what kind of mood are you in? Are you in a good mood, a bad mood or somewhere in between? Mark somewhere on this line to show how you are feeling.”

- “And today, how motivated, or excited, are you feeling to do math? Not at all motivated, very excited, or somewhere in between?”

- “And right now, how are you feeling? Awake, tired? A little awake, a little tired? Somewhere in between?”

- “Okay, now we are ready to get started on some math questions!”

*Note: On the first few sessions some additional explanation may be needed to explain the scale and the ends of the continuum. If necessary, the instructor talked through how they were feeling and how they would mark it on the page. For example, they would say “Hmm, well let’s see how I would mark it. Today I am in a little bit of a good mood, but not a super good mood, so I would mark it here, like this.” Etc.*
2. Guided Exploration (5 minutes)

**Goals:** Help to foster self-regulated learning, help students gain an understanding on what is required to be an effective learner in math, and build confidence for addressing future challenging math questions.

**Prompts and Queries:** “what do you think the question is asking you to do?”, “what can you do to find the answer?”, “tell me more about that”, “what has worked before?” “what clues did the question have to help you find the answer?”

**Sample Script:**

- Okay, now we are going to get started on working on some math problems. Here is the first problem (reads problem) the zoo has 11 horses, and 8 zebras. How many animals does it have altogether?
- Now what do you think this question is asking us to do?
- What information do we already have from the question to help us find the answer to how many animals there are altogether?
- What can we do to find the answer to the question?
  - What have we done before? What has worked for you before?
- What clues were there in the question that helped you to decide what we are looking for?
- **Transition to direct instruction - Tie students strategy use to strategy that will be taught and point out similarities and differences**
  - Hmm, the story is telling us about the different animals, but what do you think the question is asking us to help them find out?
That’s right, story is asking is to find out how many animals there are all together.

I like how you circled the numbers that were in the questions. Some students after they circle the students, write them down like this to help them find the answer.

3. **Direct Instruction** *(15-20 minutes)*

**Goals:** Work through three problems with the student to help generate understanding of how to solve math word problems while also encouraging students to self-evaluate their strategy use and reflect on what worked for past questions. General goals of the instruction were having the student retell the story in their own words, identify what the problem is asking, organize the information from the word problem, underline key words in the word problem, circle the numbers, and check that the answer they get makes sense.

**Prompts and Queries:** “what do you think the question is asking you to do?”, “what can you do to find the answer?”, “tell me more about that”, “what has worked before?”

**Sample Script:** Script is a modified version of the scripts outlined in Solving Math Word Problems *(Jitendra, 2007).*

- Today we are going to use diagrams like the ones we learned before to solve change word problems. Let’s review change problems, they always have a beginning, a middle where there is a change, and an ending. The beginning, middle, and change, all describe the same object.

- Okay I’m going to read you the problem. No, you tell me the problem in your own words.
  - What do you know? What are you asked to find out?
What is the question asking us to find out more about?
Are we being asked to add or subtract? How do you know?
What kind of problem is it? What is the beginning the middle and the end?

Now that we understand what the question is asking us we are ready for the next step.
Let’s draw our change diagram. A change problem always has a beginning, middle or change, and end. Let’s draw a shape for each step and add the arrows.

Now we need to find out what information goes into which box. Let’s underline and label some parts of the question to help us.

Let’s read the story and find what parts are the beginning, change, and end.

Read a portion. Does this sentence tell us about the beginning, change, or ending, or none of those parts?

If the information isn’t necessary – let’s cross this out because we don’t need this information to solve the problem.

If a number is identified by the student, it is circled and written in the appropriate shape

Finally, is the question asking us to add or subtract? How do you know?

This question uses the word more. Let’s underline more. More tells us that we are adding. Let’s put a plus sign between the first two boxes.

Okay, we underlined the important information, circled the numbers, and wrote them in the diagram. We found out that we have to add because we need to solve for the total.

Our number sentence is ready for us to find the answer. Let’s look at the diagram and read what it says $12+4=\text{solve that problem}$
• If student was struggling would encourage student to engage in other strategies to solve the math problem
  ▪ What are some things you do in class to find the answer to a question like this?
  ▪ Should we draw a number line or some pictures to help us find the answer?
• That’s right! The correct answer is 16, so we can write it in the final box.
• Last step is checking the answer, does 16 seem right? Yes, because it is more than the two numbers we added
  • Let’s review this change problem. There is a beginning, a change, and an ending, and we began and ended with the same things. The change involved the thing. What’s this problem called, why?
  • Great, let’s work on another problem together.

Repeat with problems 2 and 3.

4. Progress Monitoring (5 minutes)

Goals: Have the child demonstrate their learning and proficiency on solving math word problems

Prompts and Queries: “Go ahead, just do your best.” “It’s okay to take a guess if you’re not sure.”

Sample Script:

• “Okay, now you are going to work on some similar questions by yourself. Remember just to try your best”
• If the child does not start working on the problems or asks a question the prompts listed above were provided.

5. Revise and Reflect (10 minutes)

Goals: Have child reflect on their math performance and further their understanding

Sample Script:

• I could tell how hard you worked on those math questions let’s take a look at what you did.
• What was this question asking you to find? What clues were there in the question to help you figure that out?
• I like how you circled the numbers that were in the questions that is a great first step in finding out what information we already have
• I like how you also underlined the key words. How did you decide what words to underline?
• Tell me what you were thinking when you were doing this part? That’s right! Drawing a shape like that can help us to write a number sentence and figure out the answer to the question.
• So now we have our number sentence and it says 11 + 8 = What did you do to find the answer to that?
• That’s great, I like how you drew a number line to help you find the answer.
• Let’s double check that your answer makes sense, when we add 11 and 8 would we expect it to be a number that is bigger or smaller than 11?
• That’s right a bigger number. Since the answer we got is smaller than 11 let’s double check our adding on the number line
• There we go, now we have the right answer! Great work and great job using all the tools and tricks we learnt today to help us find the answer. Let’s see what you did for the other two (repeat)

*Note: If the student got a question wrong, they were encouraged to try different strategies as necessary with assistance until they found the correct answer. The student was told if their answers were correct or “that’s not quite right”. The researcher then queried the student as needed with the similar probes as during the guided exploration to help them to reflect on their work: what did you do to find the answer?” “what do you think the question is asking you to do?” “what did we do before to find the answer?”, “what are some steps we did before to find the answer?”, “tell me more about that”, “what has worked before?”.

6. Looking Back on Today’s Session Questionnaire

**Goals:** Help the child to reflect on how the child felt during the session and promote metacognition. Measure the child’s state math anxiety and math self-confidence.

**Prompts and Queries:** “Go ahead, there are no right or wrong answers”

**Sample Script:**

• Okay, last thing before you go today. We are going to answer some questions about the work we did together today. Remember, there are no right or wrong answers.

• While working on math today, how did you feel? Good, bad, or somewhere in the middle? Mark on the line how you are feeling.

• And did you feel worried, calm? Somewhere in the middle? Mark on the line how you are feeling.
• And how good at math do you feel today? Worse than your friends, about the same, better than your friends, or somewhere in between? Mark on the line how you are feeling.

• Okay, now I am going to read you some questions. Remember can answer, yes, kind of, not really, or no.
  o Read through questions and answer options

• Now I’m going to ask you some questions about the math we did today. The first few questions you can just answer yes or no.
  o Read through questions

• And what did you do while doing math today that was successful? What worked well?

• What strategies or steps have you used or learnt before that could have helped you?

• What are you going to do next time you have a question like that? Or a hard math question?

• Thanks for all your hard work today! I’ll see you tomorrow.
## Appendix F.

### Session Fidelity Checklist

<table>
<thead>
<tr>
<th>Session Date</th>
<th>Participant Number</th>
<th>Before today's session</th>
<th>Guided Exploration (3 problems)</th>
<th>Direct Instruction (3 problems)</th>
<th>Progress Monitoring (3 problems independently)</th>
<th>Revise and Reflect</th>
<th>After today's session</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2</td>
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</tr>
<tr>
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