WHAT ABOUT MATHEMATICAL METACOGNITION?

by

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DEDICATION

In dedication to my family. To my mother, the education rock star, you are an amazing role model. To my father, you showed me how to aim high and go after my dreams. Thank you both for being the best parents I could have ever imagined. To my daughters, Isabella and Miyah, thank you for being patient with me, and I hope that you both achieve your greatest dreams. To Caleb, my voice of reason, thank you for enduring with me. Lastly, I dedicate this work to Aunt Jeanette and Uncle Gary, I wish you were both here to celebrate this day with me. I love you all!

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ABSTRACT

Problem solving is an aspect of mathematics that often proves difficult for many learners. The difficulty not always founded in a lack of mathematical knowledge, but also in the lack of experience to effectively activate existing knowledge, self-monitor, and reflect during problem-solving (Schoenfeld, 1992). This study investigated how primary teachers' application of explicit instruction in the use of self-regulated learning (SRL) strategies affect students' (a) regulation of cognition (ROC) (b) and influence ability to solve whole number addition and subtraction problems in contextual settings. A quasi-experimental group design was used with a sample of first-and third-grade participants. SRL strategies were embedded in daily problem-solving activities, including SRL checklists and self-questioning verbalizations. Pre/post, measures quantified ROC and whole number addition and subtraction responses. A two-way ANOVA was conducted to compare performance scores between treatment and comparison groups. The results indicate no differences in the overall performance of the study variables for grade one and grade three participants. The findings of this study and recommendations for further research will follow.

Keywords: *self-regulated learning (SRL), regulation of cognition (ROC)*

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LIST OF ABBREVIATIONS

CCSSM	Common Core State Standards for Math
Jr. MAI	Junior Metacognitive Awareness Inventory
KOC	Knowledge of Cognition
ROC	Regulation of Cognition
SRL	Self-regulated learning

CHAPTER ONE: INTRODUCTION

Background for the Study

Metacognition, the ability to monitor and modify one's learning has been the focus of study for decades. It is a broad construct examined through many lenses: within the field of psychology (Bandura, 1982), through the disabled learner (Desoete, 2012; Desoete, Roeyers & Buysse, 2001; Montague, 1992; Palincsar & Brown, 1987; Thompson & Thompson, 1998), within secondary and adult populations (Fortunato, Hecht, Tittle, & Alvarez, 1991; Goos & Galbraith, 1996; Pape, Bell, & Yetkin, 2003; Schoenfeld, 1985; Schraw & Dennison, 1994), and across content areas, as math and literacy (Brown, 1978; Cross & Paris, 1988; Davey, 1983; Hattie 2009; Jacobs & Paris, 1987). Falling under the umbrella of metacognition are two sub constructs: knowledge of cognition (KOC) and regulation of cognition (ROC). This research will further examine ROC and the use of self-regulated learning (SRL) strategies. ROC refers to one's ability to monitor and control cognitive processes. SRL is the use of selected strategies, formal or invented, that one applies to achieve the desired outcome, monitoring and adjusting strategies as needed, and reflecting on processes used to achieve the goal. Keeping in mind the complexity of the constructs that comprise metacognition, access to population, and resource restraints, the focal point for this study will narrow and investigate ROC, SRL strategies, and the potential academic outcomes related to their use. The aim of this study is to contribute to the existing body of metacognitive research, specifically investigating how primary teachers' application of explicit instruction of self-regulated learning (SRL) strategies may affect ROC and influence students' ability to solve whole number addition and subtraction problems in a contextual setting. Ability to solve whole number addition and subtraction problems in a contextual setting will be referred to as 'the ability to solve problems' throughout the remainder of the text.

Importance of the Study

The importance of the study is based on the daily observations, inspirations, and the struggles between students and teacher in the quest to learn. The study presented offers an opportunity for teachers and students alike to learn more about how we think, the processes we use to problem solve, and how we can build an interpersonal awareness in how we learn. Engaging learners in the development of a deeper understanding of ROC, through higher order thinking, justifications, and rationales, (Hattie, 2009; Marzano, Pickering, & Pollock, 2001; Vos & de Graff, 2004; Wiggins & McTighe, 2005) and the utilization of SRL strategies, has the potential to activate learning (Howard, McGee, Shia, & Hong, 2000; Pape et al., 2003; Zimmerman 1989, 2002).

Although the existing literature and research of metacognition are extensive, the need for further research of primary aged student SRL strategy use justifies this investigation. Previous studies as Tzohar-Rozen and Kramarski (2014) have examined explicit instruction of SRL strategies in problem-solving to intermediate participants, but what makes this study unique is in the manner that teachers delivered explicit instruction of SRL strategy use to primary aged children in the domain of mathematics. In the interest of this study, the researcher intends to add to the existing body of metacognitive research, specifically investigating how primary teachers' application of explicit instruction of SRL strategies may affect ROC and influence students' ability to solve problems.

Research Questions and Hypotheses

The study examined two central research questions:

1. Does explicit instruction in metacognitive SRL strategies influence students' ROC?

    Hypothesis 1: Student ROC will increase in the treatment group as a result of explicit instruction and repeated practice in metacognitive SRL strategies.

2. Does explicit instruction in metacognitive SRL strategies influence students' abilities to solve whole number addition and subtraction problems in contextual settings?

    Hypothesis 2: Students' ability to solve whole number addition and subtraction in a contextual setting will increase in the treatment group as a result of explicit instruction and repeated practice in metacognitive SRL strategies.

Definition of Key Terms

Ability to solve problems-Students ability to solve whole number addition and subtraction problems in a contextual setting.

Cognition-Garofalo and Lester (1985) referred to cognition as "involved in doing" (p. 164). Cognition includes the actions or processes used to manage information and the observation and manipulation of objects. Vos and de Graff (2004) describe cognition as:

> "Cognition" includes knowledge, skills, experiences and the information in symbolic form that goes with them. Cognition is the faculty of knowing, including being able to write, read, measure, construct, observe and understand instructions for tasks and information. Cognition is related to material objects, to spoken information and/or written material. (p. 544)

Explicit Instruction- A systematic and sustained approach used for teaching skills or processes including the sequencing of content, modeling of processes, and supported practice. Instructional support remains in place until students are able to show evidence of success. Eventually, teacher's support is systematically withdrawn, and the students move toward independence (Archer & Hughes, 2011).

Knowledge of Cognition (KOC)-Knowledge and personal perspective about cognitive processes (Schraw, 1998) including declarative, procedural, and conditional knowledge. Pintrich (2000) further expands this construct to include knowledge of general strategies, knowledge of conditions, knowledge of effectiveness, and knowledge of self. Cognition of self is how processes and actions relate to the one's self.

Metacognition-The definition of metacognition varies across research. Metacognition involves and encompasses an awareness or analysis of one's learning or thinking processes, the ability to activate prior knowledge, control and regulate cognitive processes, and evaluate outcomes. Garofalo and Lester (1985) referred to metacognition as "involved in choosing and planning what to do and monitoring what is being done" (p. 164). Two common sub constructs of metacognition are found in the literature are KOC and ROC (Brown, 1978, 1987; Flavell, 1976; Pintrich, 2000).

Regulation of Cognition (ROC)-Involves the knowledge students use to regulate one's thinking or cognition. ROC involves the learner to recall, organize and manipulate information, utilize and modify selected strategies, and monitor and evaluate outcomes. In addition the utilization of SRL strategies are employed as part of ROC and are described as "Actions and processes directed at acquiring information or skills that involve agency, purpose, and instrumentality perceptions by learners" (Zimmerman, 1989, p. 329).

Summary

The study of ROC and SRL strategies across various populations has been the subject of examination for decades. However, the research is not as extensive regarding the enlistment of classroom teachers of primary-aged students to lead treatments using explicit instruction of SRL strategies with the hope of affecting students' ROC and influence their ability to problem solve. The purpose of this study is to contribute to the existing body of metacognitive research, specifically investigating how primary teachers' application of treatment using explicit instruction in of SRL strategies may affect ROC and influence students' ability to solve problems.

CHAPTER TWO: REVIEW OF RELATED LITERATURE

Introduction

The study of metacognition is extensive. Therefore, it is helpful to examine the constructs that fall under the umbrella of metacognition. This chapter first provides a broad overview of metacognition. It then narrows specifically to constructs of interest examined in this study. Figure 1 frames the relationships between the relevant constructs into a specific theory of action related to ROC and students' ability to solve problems.

Figure 1. Logic Model

Metacognition

Born out of research on metamemory,[1] - or the study of memory and memory processes, the term *metacognition* was introduced by John Flavell in 1976. Flavell (1976) referred to this phenomenon as, "One's knowledge of one's own cognitive processes and products or anything related to them, the active monitoring or 'metacognitive knowledge'

[1] Flavell's definition, as cited by Hacker, Dunlosky, and Graesser, 1998, of metamemory and the definition of metacognition often blur lines of distinction, creating a "fuzzy concept" of the two terms. The term memory defined as "applied cognition," blur these lines.

and consequent regulation and orchestration or ‘metacognitive experience’ of these processes in relation to the cognitive objects, usually in service of some concrete goal or objective” (Flavell, 1976, p. 232). Metacognition is typically conceptualized as an elaborate structure employed by students to store and integrate knowledge to achieve a goal. Metacognition utilizes executive function to compare and regulate cognitive skills essential for one’s learning and often referred to as, “thinking about one’s own thinking” or “cognition about cognition” (Papaleontiou-Louca, 2003). Hacker, Dunlosky, and Graesser, (1998) defined metacognition to include the knowledge of one's cognition, feelings or affect and the ability to consciously and deliberately examine and regulate those processes.

Metacognition is a complex construct tied to internal representations and external processes of how one thinks (active monitoring, adjusting, and orchestrating), how things work (cognition and implementation), and how one feels regarding the task (reflection, judgments) to achieve cognitive goals. Metacognition provides learners with the skills to use previous knowledge to address new situations, link internal thinking to external processes (Carr, Alexander, & Folds-Bennett, 1994; Pilling-Cormick & Garrison, 2007), and continue learning (Papaleontiou-Louca, 2003). Metacognition is composed of two distinct constructs: knowledge of cognition and regulation of cognition (Figure 2) (Flavell, 1976; Garofalo & Lester, 1985; Schraw, 1998). KOC is the knowledge and personal perspective about cognitive processes. ROC is the knowledge students use to regulate one’s thinking or cognition. Each construct defined distinctly from the other, but are interrelated. The focus of this study is to contribute to the existing body of metacognitive research related to regulation of cognition. Specifically, this study investigates how primary teachers' application of treatment using explicit instruction self-regulated learning strategies may affect students' ROC and thereby influence students' abilities to solve problems. These relationships are depicted Figure 1.

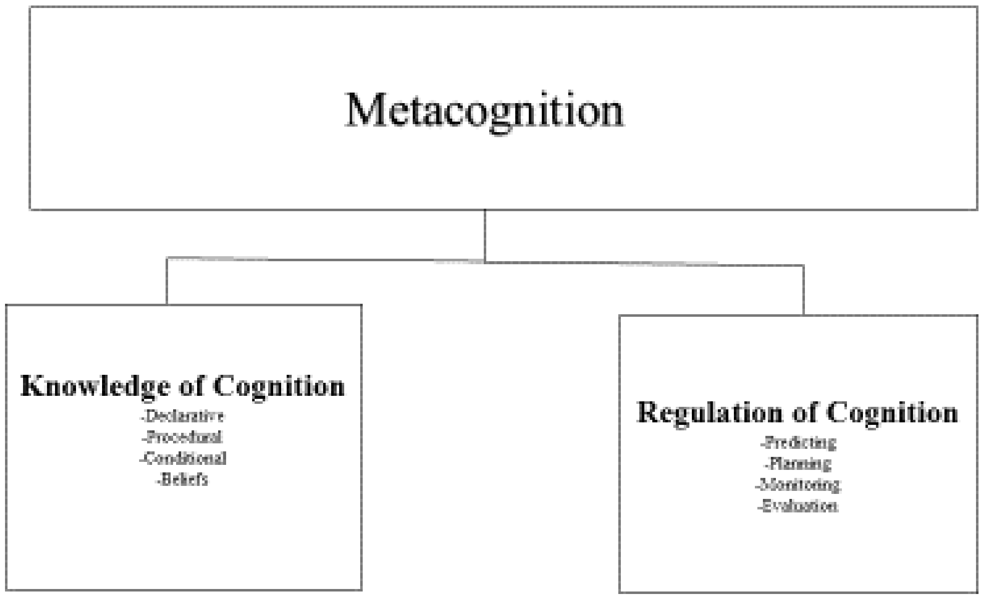

Figure 2. Metacognitive constructs in educational psychology and mathematical research.

Metacognitive Constructs

KOC and ROC are two fundamental constructs within metacognitive research. While the theory of action for this study does not include knowledge of cognition as a key construct, it is briefly described below to better situated regulation of cognition within the metacognitive research. This is followed by a description of the constructs of and related research for ROC and then SRL.

Knowledge of Cognition

KOC involves an awareness of cognition and the understanding of how it relates to one's self. As defined in key terms, cognition is the action and processes one uses in their learning. Flavell (1979) states, “Metacognitive knowledge consists primarily of knowledge or beliefs about how factors or variables act and interact in what ways to affect the course and outcome of cognitive enterprises” (p. 907). KOC is comprised of one’s experiences as constructed through declarative, procedural, conditional knowledge, and beliefs (Brown, 1987; Cross & Paris, 1988; Jacob & Paris, 1987; Montague 1992; Norman, 1980). Declarative knowledge is the knowledge we possess about ourselves, others, and the factors that influence our performance (Schraw, 1998). Procedural knowledge is the knowledge we possess knowing how we do things or perform functions (Schraw, 1998). Conditional knowledge is knowing when and why to use procedures or strategies (Schraw, 1998). For example, John knows he has difficulty recalling math facts (declarative). He has learned that if he decomposes a difficult math fact into known math facts, his likelihood of computational success will increase (procedural). He uses this strategy to solve difficult single and multi-digit multiplication problems (conditional). Flavell’s (1979) descriptors further define metacognitive knowledge into three categories: person, task, or strategy. Alex (person variable), a fifth-grade student, is taking a summative assessment on multiplication of whole numbers and fractions. He realizes that he can confidently use a standard algorithm to solve the problems regarding the multiplication of whole numbers, but is unsure about multiplying fractions using a model or equation (task variable). He will answer the questions regarding whole number multiplication first and save multiplying with fractions for last (strategy variable). After solving the problems involving whole numbers, Alex may further examine his knowledge of his own thinking, perhaps reflecting on the thoughts and cognitive processes required to extend his previous understanding of whole number multiplication to multiply fractions. Carr, Alexander, and Folds-Bennett (1994) regard KOC as a critical role in academic achievement and growth. Pintrich (2002) found that students possessing a higher level of KOC learned and performed higher than peers with limited knowledge as they improved in problem solving, and could transfer strategies to new tasks or situations.

Regulation of Cognition

ROC has been defined as “the ability to manage one’s own behavior, so as to withstand impulses, maintain focus, and undertake tasks, even if there are other more enticing alternatives available” (Boyd, Barnett, Bodrova, Leong, & Gomby, 2005, p.3). Regulating one’s own thinking according to the situational demands of the task requires metacognitive aware participants (Howard et al., 2000; Pape et al., 2003; Pintrich, 2000; Zimmerman 2002) to informatively select from known strategies, monitor their progression, and adjust strategies towards the attainment of the learning goal. Learners possessing these characteristics are active participants engaging in the acquisition and assimilation of new knowledge, self-regulation of strategies and behaviors, and utilization of prior knowledge to achieve task outcomes or goals. The following scenario details use of ROC: Jan is solving a contextual fraction task requiring her to multiply a fraction by a whole number. She will employ SRL strategies to initially scan the task and determine the ease or difficulty based on prior experience. Next, she will define the purpose of the task (in context, multiply a fraction by a whole number), whether she has seen a similar task (previous whole/small group exposure, in context or symbolically), and determine what strategy or model (mental math/repeated addition/area model/equation) to use to complete the task. She will then implement her plan. Midway through the task, she will pause and ask herself if the current strategy or model is proving effective and whether she needs to change her plan. She will then complete the task and reflect on her outcome, strategy, or model use, and whether she would use that strategy or model again in a similar task.

Zimmerman (1989) described self-regulated learners as, “metacognitively, motivationally, and behaviorally active participants in their own learning processes” (p. 329). The process of thinking about what we already know in relation to the task influences learning, aides in the interpretation of new information, and the re-organization of mental networks as a generative process inclusive of metacognition (Hiebert, Carpenter, & Grouws, 1992). Students call upon schemas to organize information into related groups, utilizing mental activities as “adaptation” and “assimilation” to incorporate new experiences into pre-existing mental structures, interpret and modify networks, and think successively. Winne (2010) described self-regulated learners as individuals who can, “… monitor the qualities of their work and exercise metacognitive control to make needed adjustments on the fly” (p. 268) with the caveat that there is purpose in modifying their plan and their work.

Self-Regulated Learning Strategies

Developing and promoting learners that can effectively utilize SRL strategies to demonstrate understanding and increase academic achievement is a goal in education (Biemiller & Meichenbaum, 1992; Sperling, Howard, Miller, & Murphy, 2002; Zimmerman, 2000). Effective ROC by students involves employing SRL strategies such as, predicting, planning, monitoring, and self-evaluation of work (Brown, 1978, 1987; Flavell, 1976, 1979; Lucangeli & Cornoldi, 1997; Schoenfeld, 1987; Van Hout-Wolters, 2000; Zimmerman, 2002) and are essential skills needed to regulate one’s cognition. SRL itself is multidimensional, recursive, (Winne, 2010) and non-linear in nature (Pintrich, 2000). Metacognitive skills and SRL strategies be nurtured, taught, and learned (Bransford, Sherwood, Vye, & Rieser, 1986; Flavell, 1979; Garner, 1990; Garner & Alexander, 1989; Tzohar-Rozen & Kramarski, 2014). In doing so, a teacher must support learners to guide strategies and regulate cognition. Learning how to manage one's learning requires explicit strategy instruction, as they are neither innate or instantaneous, and therefore need formalized explicit training to effectively apply strategies to given situations (Kramarski; Weisse, & Kololshi, 2010; Veenman, Van, Hout-Wolters, & Afflerbach, 2006). Schoenfeld (1987) refers to self-regulation as a 'management issue' asking essentially, "How well do you manage your time and effort as you are working on a complex task?" and that "One way to characterize efficient self-regulation is to say that the people who are good at it are the people that are good at arguing with themselves" (p. 210).

Pintrich's (2000) model of SRL strategies: predicting, planning, monitoring, and evaluating are the framework of this research model and are further delineated.

- *Predicting*-Involves one's ability to anticipate or recognize the ease or difficulty of a task. At the onset, students routinely assess the task to determine the rigor required to solve the problem. In doing so, adjusting their cognitive processes in anticipation of those problems viewed as easy or more difficult to complete.

  (e.g., 12 x 4=... as compared to 12 x 45=...)

- *Planning*-This phase includes students addressing the task by analyzing, retrieving, and sequencing information previously held in their schema. An example would be a grade five student addressing the task of multiplying whole numbers. Initially, the student will analyze the task, recalling previous problems similar in nature, previously used models (array, area, partial products, and algorithm) and strategies (doubles or distributive property of multiplication), and then sequencing the information to put into action.

- *Monitoring*- During the monitoring phase, students implement their plan and monitor their progress using self-regulating questioning skills. Self-verbalizations and self-questioning skills assist students in monitoring both procedurally and conceptually, as they move through the problem-solving process. Monitoring helps students to determine the effectiveness of their strategy or model and if necessary, adjust their plans accordingly. Asking questions, "such as, 'Am I following my plan?', 'Is this plan working?', 'Should I use paper and pencil to solve the division?'" (Desoete, 2008). Hacker et al. (1998) stated the "Ability to monitor one's knowledge and processes is no trivial matter as far as education is concerned" (p.12).
- *Evaluation*- Evaluation includes the student going back to check their work, calculations, and procedures. Additional items in the evaluation process include self-talk such as, "Did I answer all the questions? Do my answers make sense? Would I use this strategy/model again?"

Predicting, planning, monitoring, and evaluation can be effectively taught through explicit instruction (Archer & Hughes 2011; Camahalan, 2006; Doabler & Fien, 2013; Kistner et al., 2010; Pintrich, 2002; Tzohar-Rozen & Kramarski, 2014; Veenman, 2007). Explicit instruction is the systematic and sustained approach used for teaching skills or processes including the sequencing of content, modeling of processes, and supported practice (Archer & Hughes, 2011). Explicit instruction, designed to develop SRL strategies, has the potential to encourage reflection of learning strategies and goals (e.g. Fuchs et al., 2003), invoke reflective questioning, influence the sharing of strategies among peers, and allow opportunities for students and teachers to maximize effectiveness of a task (e.g. Bryant & Bryant, 2008).

Studies examining explicit instruction and modeling of SRL strategies to develop cognition and increase metacognition skills in children have proven effective (Butler & Winne, 1995; Desoete, 2008; Pintrich, 2000; Schraw, 1998; Tzohar-Rozen & Kramarski, 2014; Zimmerman, 2000) As shown in figure 1, embedding explicit SRL strategies into domain specific activities may affect student ROC and influence student mathematical outcomes. Research designed to examine student use of SRL strategies have reported increased achievement among participants (Biemiller & Meichenbaum, 1992; Carr et al., 1994; Garofalo & Lester, 1985; Kramarski & Mevarech, 2003; Pintrich, 2000; Schoenfeld, 1987, 1992; Tzohar-Rozen & Kramarski, 2014).

Tzohar-Rozen and Kramarski (2014) examined explicit instruction of SRL strategies in problem-solving study. The study based on the principles of Pintrich's (2000) model, investigated if SRL affected student metacognitive regulation, motivational-emotional regulation and problem solving. Participants in this study were 118 grade five students. Students were randomly assigned into two groups; the metacognitive regulation group or the metacognitive motivational-emotional regulation group. Intervention for both groups was 10 hours for five weeks. Both groups received an intervention. Intervention was administered by teachers trained in SRL strategies in the metacognitive regulation group with additional training in student belief and performance strategies in the motivational-emotional regulation group. Explicit instruction of SRL strategies were embedded within daily whole group problem solving.

Researchers found a modest improvement in self-regulation in the metacognitive regulation group and comparable achievement growth and results in both groups. The researchers concluded that if you deliver explicit instruction in SRL strategies, regulation of cognition would improve. They found that if you nurture either part of self-regulation; metacognitive regulation or emotional regulation that it will improve learner achievement. If one "nurtures" any one aspect of self-regulation, it in turn, affects the self-regulation process as a whole, "leading to an improvement in the learner's achievement" (p. 90).

Fuchs et al. (2003) studied the use of explicitly taught SRL strategies in problem-solving and transfer with 395 randomly selected grade three students. The researchers chose the problem-solving domain as it is "well suited" for metacognition, SRL strategy use, and generally requires perseverance (p. 313). The duration of the study was 16 weeks, 30 sessions, and 2 cumulative review sessions. The researchers created two groups for the study: a transfer treatment group and a transfer plus treatment group. The transfer treatment group included instruction based on rules for problem-solving, teaching transfer, and review and the transfer plus treatment group received the same information but with SRL components intertwined in instruction. Each group received their first problem transfer lesson taught explicitly by research assistants with classroom teacher present. Consecutive lessons were taught by teachers with research assistants present for the majority of the study and scripts from the lessons were reviewed for consistency in instruction.

SRL was measured using the assessment, “What Do You Think?” Participants were assessed pre and post in problem solving and SRL processes. Researchers found that the transfer plus treatment group, those receiving explicit instruction combined with SRL, had a stronger improvement in transfer as compared to the control group. Researchers found that instruction associated with SRL promotes SRL processes as well as learning.

The present study is similar to Tzohar-Rozen and Kramaraski’s (2014) research regarding utilizing teachers to deliver explicit instruction in metacognitive SRL strategies and the examination of the influence these strategies may have on academic outcomes. However, this study differs in the age of the participants involved. The aim of this study is to contribute to the existing body of metacognitive research, specifically investigating how primary teachers’ application of treatment using explicit instruction SRL strategies may affect ROC and influence students’ abilities to solve problems.

Statement of Focus of the Study

The study intended to examine two central research questions:

1. Does explicit instruction in metacognitive SRL strategies influence students’ ROC?
2. Does explicit instruction in metacognitive SRL strategies influence students’ abilities to solve whole number addition and subtraction problems in contextual settings?

CHAPTER THREE: METHODOLOGY

The goal of this study is to investigate how primary teachers' explicit instruction in the use of SRL strategies affect students' ROC and the ability to solve problems. This study's quasi-experimental pre and-post design is depicted below in Table 1. All students involved in the study were assessed on ROC and the ability to problem solve prior to and following intervention. The treatment group received instruction in SRL strategies in conjunction with cognitively guided tasks. The comparison group received instruction on cognitively guided tasks only with no instruction in SRL strategies.

Table 1 Quasi-experimental pre-post design

	Pre-test	Intervention	Post-test
Treatment Group	Mathematics Achievement ROC	10 days of instruction in SRL strategies in conjunction with CGI tasks	Mathematics Achievement ROC
Comparison Group	Pre-test	Intervention	Post-test
	Mathematics Achievement ROC	10 days of CGI tasks only	Mathematics Achievement ROC

Based on Polya's 1945 problem-solving framework and Pintrich's 2000 theoretical work in student use of ROC, the researcher used this combined framework to create the outline for the treatment as presented in Table 2.

Table 2 Pintrich's Phases and Areas for Self-Regulated Learning Framework and Polya's Model of Self-Regulation Questioning

Pintrich's Phases Self-Regulated Learning			Polya's Model Self-Regulation Questioning		
Pre-learning	• Forethought • Planning • Activation	Examination of: • Goal Setting • Activate-Prior Knowledge and Metacognitive Awareness • Task Comprehension • Planning	Pre-learning	• Understand "what" must be done (Predicting) • Devise a plan and find a connection between data and unknown (planning) • Understand problem • Examine known and missing data	• "Do I understand the task?" • "Have I solved a similar task?" • "Which strategy should I choose?"
During-learning	• Monitoring • Control	Examination of: • Meta-awareness • Monitor cognition • Strategy and efficacy	During-learning	• Carry out plan, check each step, prove correctness, and consider alternative strategies (monitoring)	• "Is my chose strategy effective?" • "How do I choose a different strategy?"
Post-learning	• Reaction • Reflection	Post problem solving: • reflection on • solution process	Post-learning	• Was it easy/difficult? Why? • Can I solve a different way? • Can I check the result? • Can I use the method for another problem? (Evaluation)	• "Is the solution reasonable?" • "Could I have solved it a different way?"

Note. Adapted from "The role of goal orientation in self-regulated learning," by P.R. Pintrich, 2000, *Handbook of self-regulation: Research and application,* p 454. Copyright 2000 by Academic Press and from "*How to solve it: A new aspect of mathematical method,"* G. Pólya, 1945, p. xvii. Copyright 1945 Princeton University Press.

Participants

Study participants were 64 grade one and three students who attend a school in Idaho. The school is a Title 1 school with 78% of the students eligible to receive free or reduced lunch. The treatment groups consists of 17 grade one students (T1) and 18 grade three students (T3). The comparison groups consist of 14 grade one students (C1) and 15 grade three students (C3). The typical age range of the students was 6-7 years old for grade one and 8-9 years old for grade three.

Four teachers participated in the study, each delivering the intervention described in Table 2 within their respective classroom. Grade one teachers had one year and five years of teaching experience. Grade three teachers had 5 and 27 years of teaching experience.

Timeline

The study was conducted in April and May of 2016. Treatment teachers participated in a four-hour training session designed to familiarize them with the findings of research on metacognition, ROC, explicit instruction of SRL strategies in the mathematics classroom, and modeling the use of self-regulatory checklists in conjunction with Cognitively Guided Instruction (CGI) tasks (see Appendices A, B, and C). Self-regulatory checklists support students in the decision-making process and served as an aid for planning, monitoring, and self-evaluation. Checklists provide the learner with the continuous use of planning and decision-making strategies and establish the norm of using self-regulatory strategies (Schraw, 1998).

Comparison teachers participated in a one-hour training session focused on the use of cognitively guided tasks only (see Appendices D and E). Treatment and comparison groups administered pre-and-post CGI word problem assessments and the Jr. MAI (see Appendices F, G, and H). Treatment and comparision groups followed the administration of the pre-assessments for 10 days see Table 3.

Table 3 Timeline of Treatment and Comparison Groups

Phases	Treatment Groups	Comparison Groups
Prior to Measurement Administration and Treatment	Grades one and three teachers trained on explicit instruction of SRL strategy use in conjunction with cognitively guided tasks, regulatory checklists, the delivery of the CGI word problem assessment, and the Jr. MAI inventory.	Grades one and three teachers trained on cognitively guided tasks, delivery of the CGI word problem assessment, and the Jr. MAI inventory.
Measure Administration Days 1-2	CGI word problem assessment (see Appendices F and G) Jr. MAI (see Appendix H)	
Treatment Administration Days 3-13	Day 3: Build Mind Map portraying SRL strategies and model explicit SRL strategy use.	Days 4-13: Daily cognitively guided tasks without regulatory prompts or post-task modeling.
	Days 4-13: Daily cognitively guided tasks with regulatory prompts and post-task modeling of SRL strategies and regulatory checklist use.	
Measurement Administration Days 13-14	CGI word problem assessment (see Appendices F and G) Jr.-MAI (see Appendix H)	

Intervention Descriptions

<u>Treatment Group</u>

Treatment teachers in grades one and three participated in one-4-hour professional development session. The researcher discussed evidence of explicit instruction of SRL strategies affecting ROC and influencing students' abilities to solve problems (Biemiller & Meichenbaum, 1992; Carr et al., 1994; Pape et al., 2003; Schraw, 1998; Schraw & Dennison, 1994; Zimmerman, 2002; Zimmerman & Martinez-Pons, 1988). Based on Polya's 1945 problem-solving framework and Pintrich's 2000 theoretical work in student use of ROC, the researcher used this combined framework to create the outline for the treatment. Teachers and the researcher used this framework to co-construct grade appropriate SRL mind maps to use with students as presented in Table 2.

Following training, teachers used their grade level appropriate SRL mind map to discuss strategy use with students. Teachers discussed the benefits of using before, during, and after strategies as part of the problem-solving process. Daily cognitively guided tasks with SRL prompts were practiced in a whole group setting by students for 10 days. Teachers read cognitively guided question aloud and then chorally read by students and teacher. Before, during and after task questions were read in the same manner. ‘During’ task questions were prompted at a 45-second mark. Students were explicitly instructed to circle answers to each question after it was read. At the end of each session, the teacher used a think-aloud strategy to explicitly model SRL strategy use and solve the cognitively guided task. A think-aloud serves as an important instructional scaffold technique for teaching higher-level cognitive strategies and enhancing learning (Davey, 1983; Hattie 2009; Raihan, 2011).

Treatment took place in the general education classroom during regular math lessons. Two unannounced implementation fidelity checks occurred over the duration of the treatment. Fixsen, Naoom, Blasé, and Friedman (2005) found treatments administered with complete fidelity could expect positive student outcomes. The first check occurred at the onset of the treatment, and the other check was in the middle of the second week.

Comparison Group

Comparison group teachers introduced the cognitively guided task packet; each read aloud by the teacher and then chorally read by students and teacher. Prompts were excluded from this group. Teachers introduced a new cognitively guided task daily in a whole group setting for 10 days and helped as needed.

Measures

Two inventories were administered to assess the constructs of this study. ROC was measured using the Jr.MAI-Version A and students’ ability to solve problems was measured using a CGI Word Problem Assessment.

Jr. MAI-Version A

The Jr. Metacognitive Awareness Inventory (Jr. MAI-Version A), a modified version of the Schraw & Dennison (1994) Metacognitive Awareness Inventory, originally designed to measure self-regulatory constructs and knowledge of metacognition in adults, was used to measure ROC and KOC. Although the Jr.MAI-Version A was designed to measure both ROC and KOC, this study examined ROC. Data collected for KOC was excluded.

The Jr. MAI-Version A is a shortened, more easily administered inventory, developed for grades three through five. Consisting of a twelve Likert-scale, the Jr. MAI measures subscales for ROC and KOC in younger children. It is designed with the intent to "address the relationship between achievement and metacognition" (Sperling et al., 2002, p. 72), 'screen' students for "potential metacognitive and cognitive strategy interventions, and used as an assessment tool to determine the effectiveness of ongoing interventions" (Sperling, et al., 2002, p. 57). For the current study, the measure was modified regarding the number and wording of the items. Tzohar-Rozen and Kramarski (2014) used the Jr. MAI-Version A as a pre and post intervention measure and found improved regulation of cognition among grade five metacognitive component participants. While Sperling, Howard, Miller, and Murphy, (2002) stated that the instrument needs further examination (p.74) they found the Jr. MAI-Version A to be a viable tool for those who are studying self-regulatory constructs.

Classroom teachers administered the Jr.-MAI-Version A pre-and-post measures. Grades one and three teachers read questions aloud to students and provided no further assistance. The researcher modified the written directions on the inventory to fit the domain of the study, using an emphasis on mathematics (see Appendix F). Each item on the twelve-item inventory was scored on a three-point scale ranging from 1 (Never) to 3 (Always). A two-way ANOVA provided data on both pre-and-post measures.

<u>CGI Word Problem Assessment</u>

The CGI task framework was developed at the Wisconsin Center for Education Research (Carpenter, Fennema, Franke, Levi, & Empson, 1999) to develop and facilitate primary students' mathematical thinking and reasoning. Additionally, these tasks provide opportunities for teachers to increase understanding and analyze student responses regarding cognitive development. For the current research, the CGI tasks were designed and based upon Carpenter, Franke, Levi, and Empson (1999) framework and used to assess achievement. The CGI items used evaluated whole number addition and subtraction. The CGI word problem types allowed students flexible choice of strategies and models including; direct modeling strategies, counting strategies, and derived facts. Additionally, they require some use of prior knowledge recall and, most importantly for this study, provide an opportunity for SRL strategy use. The Common Core State Standards for Mathematics (2010) (CCSSM) recommends the use of common addition and subtraction problem types (p. 88), like the problem types found in the Carpenter et al. (1999) publication. The researcher followed CCSSM 1. OA.A.1- "Use addition and subtraction within 20 to solve word problems involving situations of adding to, taking from, putting together, taking apart, and comparing, with unknowns in all positions, e.g., by using objects, drawings, and equations with a symbol for the unknown number to represent the problem," to create cognitively guided tasks for grade one. For grade three, the researcher adapted the number set, per the CCSSM 3.NBT. A.2- "Fluently add and subtract within 1,000 using strategies and algorithms based on place value, properties of operations, and/or the relationship between addition and subtraction, "to create cognitively guided tasks. Carpenter, Fennema, Peterson, Chiang, and Loef (1989) found that student use of CGI tasks yielded a higher level of achievement in problem solving than in comparison classes.

Due to the lack of availability of a pre-existing general mathematics computation measure, aligned with the criteria of this study and transferability across grade levels, the researcher created the pre-and-post CGI word problem assessment. Classroom teachers administered the CGI word problem pre-and-post assessment. Grades one and three teachers read questions aloud to students and provided no further assistance. The researcher assigned scores of 0 (Incorrect) or 1 (Correct) for each of the twelve items on the assessment. A 2-way ANOVA was conducted on data from both pre-and-post measures.

CHAPTER FOUR: FINDINGS

Introduction

The purpose of this chapter is to present the analysis of the data gathered. The study sought to answer the following questions.

1. Does explicit instruction in metacognitive SRL strategies influence students' ROC?
2. Does explicit instruction in metacognitive SRL strategies influence students' abilities to solve whole number addition and subtraction problems in contextual settings?

To address these questions, a two-way ANOVA was conducted on data from pre- and -post assessments of ROC and students' abilities to problem-solve.

Descriptive Statistics

Regulation of Cognition

For ROC, there were 2 factors with two conditions each; therefore, this was a 2 (Time: pretest versus posttest) x 2(Treatment: Intervention and Comparison) ANOVA. There was not a significant main effect for Time $F(1, 62) = 0.02$, MSe = 0.001; $p = .88$. This indicates students ROC did not change from pre to post intervention. There was not a significant main effect for Treatment $F(1, 62) = 1.565$, MSe = .59; $p = .22$. This indicates students ROC did not differ by treatment. Most important, the interaction was not significant, $F(1, 62) = 0.08$, MSe = .004, $p = .78$; which suggests the change from pretest to posttest did not differ across treatments as seen in Table 4.

Table 4 Regulation of Cognition-Grades One and Three

Source	*n*	Pre-ROC		Post ROC	
		mean	SD	mean	SD
Intervention	35	2.28	0.35	2.26	0.51
Comparison	29	2.13	0.49	2.13	0.51

<u>Whole-Number Addition and Subtraction</u>

For achievement, there were 2 factors with two conditions each; therefore, this was a 2 (Time: pretest versus posttest) x 2(Treatment: Intervention and Comparison) ANOVA. There was a significant main effect for Time $F(1, 62) = 8.99$, MSe = 1365.18; $p = .004$. This indicates students' achievement did change from pre to post intervention. There was not a significant main effect for Treatment $F(1, 62) = 0.01$, MSe = 18.5; $p = .89$. This indicates students' achievement did not differ by treatment. Most important, the interaction was not significant, $F(1, 62) < 1$, MSe = 160.55, $p = .31$; which suggests the change from pretest to posttest did not differ across treatments as seen in Table 5.

Table 5 Achievement-Grades One and Three

Source	*n*	Pre-CGI		Post CGI	
		mean	SD	mean	SD
Intervention	35	58.57	26.85	67.38	24.28
Comparison	29	60.06	23.93	64.37	17.94

CHAPTER FIVE: DISCUSSION

The goal of this study examined the explicit use of metacognitive SRL strategies in grades one and three classrooms, specifically in the domain of mathematics. An analysis of pre-and-post data followed a 10-day intervention cycle. Measures relating to student use of SRL strategies while solving cognitively guided tasks were quantified and analyzed. The Jr. MAI-Version A used to measure ROC was quantified and analyzed. Based on the data collected, there was no significant effect identified in ROC or students' ability to problem-solve.

Implications

This research study focused on the influence teacher-led explicit instruction and modeling of SRL strategies had on ROC and ability to problem solve. The following questions presented a point of inquiry.

1. Does explicit instruction in metacognitive SRL strategies influence students' ROC?

2. Does explicit instruction in metacognitive SRL strategies influence students' abilities to solve whole number addition and subtraction problems in contextual settings?

The findings of the current study conclude that teacher-led, explicit instruction of SRL strategies does not affect ROC or influence students' ability to problem-solve. One could argue those findings based on the following limitations that may have adversely affected the outcome of this research.

Limitations and Assumptions of the Study

Instrument Reliability and Availability

Although much time and research have gone into creating measures in the domain of metacognition (Desoete, 2008; Jacobse & Harskamp, 2012; Schraw & Dennison 1994; Sperling et al., 2002; Whitebread et al., 2009; Winne, 2010), the researcher found the identification of a measure that appropriately operationalized both ROC and whole number computation in primary aged students to be a challenge.

The researcher used Sperling et al. (2002) Jr. MAI-Version A to measure ROC. A perceived limitation of the Jr.MAI-Version A was the need to adapt the instrument's language for primary aged students grade one. For example, Sperling et al. (2002) used the prompt "I am a good judge of how well I understand something" versus the adapted prompt for this study "I know when I understand something". These slight modifications of a previously studied instrument may have adversely affect the reliability of the measure.

A second perceived limitation of the inventory was that each item was scored on a three-point scale 1 (Never), 2 (Sometimes), and 3 (Always). As a result, pre- and -post data may have been adversely impacted due to the fact that a 3-point scale was not sensitive enough to capture a change in ROC in 10 days.

Unable to find a satisfactory whole number computation assessment, the researcher used Carpenter et al. (1999) research to create a cognitively guided assessment to operationalize primary aged students' ability to solve whole number addition and subtraction problems in a contextual setting. The limitations of this novel assessment instrument are that (a) it was created by the researcher of whom is not a content expert and (b) it had not piloted before the start of the study.

Sample Size

The study used a convenience small and had a small sample size. Small samples threaten the reliability of a study and it is difficult to make conclusions regarding the findings of an intervention (Hacksaw, 2008). While convenience sampling allows ease of access to populations, the limitations include; inability to generalize, selection bias, and sampling error (Johnson & Christensen, 2012). The researcher recognizes the small sample size of this study as a possible limitation.

Non-Random Sampling

Based on a convenience and willingness to participate, a convenience sample determined the participants for this study. Additionally, the researcher determined classroom assignments, intervention or comparison, based on previous knowledge of participating teachers. Use of non-random selection creates biased samples and an inability to generalize across a population (Johnson & Christensen 2012).

Attrition

The study recognizes attrition of study participants as a threat to internal validity. Attrition of study participants affects the potential generalizability of the study. Schulz and Grimes (2002) state that loss to follow up of 20% or more presents greater threats to validity. It is recommended that partial data be included in future research as total participation attrition due to incomplete work accounted for a (N=14) or a 31% loss of data in grade one and a (N=10) or a 23% loss of data in grade three. The inclusion of partial work in future studies will maximize participation effect size and possibly influence statistical outcomes. Additionally, a contributing factor to attrition was likely a result of a highly mobile population at a Title 1 school.

Time Constraints

The issue of the time allocated to the treatment of the study must be addressed as a variable that may have had a negative impact on the statistical outcome of the study. Intervention occurred over the course of 30 minutes per session for 10 days, approximately 5 hours. Explicit instruction of SRL strategies and metacognitive awareness requires both time and repeat practice (Butler & Winne 1995; Desoete 2008; Desoete et al., 2001; Schraw 1998). More time is needed to implement a well-rounded course of treatment to ensure students are exposed to explicit modeling of cognition (performance of the task; declarative, procedural, and conditional), modeling of metacognition (thinking regarding the task), and repeated, sustained SRL strategy practice. An aspect of previous research, yielding positive findings, in similar studies, revealed longer spans of treatment time 5 months (e.g. Carr et al., 1994), 16 weeks (e.g. Fuchs et al., 2003), and 10 weeks (e.g. Tzohar-Rozen & Kramarski, 2014). The researcher feels that given a longer period for treatment, the results may have yielded positive outcomes on student ROC and ability to problem-solve.

The assumption for this study is that participants completed the Jr. MAI-Version A and CGI word problem assessment to the best of their ability.

Recommendations for Future Research

The researcher recommends that further research is needed to examine teacher-led explicit instruction of SRL strategies, and the influence it has on ROC and cognitively guided tasks. Given sufficient time to fully implement a longitudinal study based on the methods discussed in this paper and explicitly teaching mathematical metacognition using real-world application may in the future yield different results than those found in this research.

Additionally, the researcher recommends the use of qualitative measure as think-aloud interviews in conjunction with a strategy transfer task. Researchers studying metacognition and problem-solving in elementary aged children (Swanson, 1990) used interviews as a qualitative, sometimes quantitative, method for assessing students' metacognition. Interviews and strategy transfer tasks provide authentic opportunities to examine student's internal representations, cognitive processes, and gain insight into student understanding (Hiebert et al., 1992). Think-aloud interviews paired with novel transfer tasks can provide information on metacognitive processes during the task regarding student thinking, independent application, use, modification, or abandonment of SRL strategies. Think-aloud or concurrent report interviews allow direct, observable insight into student thinking, and provide a qualitative measure to explain student understanding.

For future research and as an extension to the current study, it would be useful to examine the use of explicit instruction of mathematical practices and SRL strategies across populations, examining individual levels of performance and achievement.

Conclusions

The purpose of this study was to explore teacher use of explicit instruction of SRL strategies to increase ROC and influence primary aged students' ability to solve problems. Implementing and explicitly teaching the awareness of metacognition in the classroom collectively or in isolation of underlying constructs: knowledge of cognition, beliefs, or regulation of cognition, are effective tools for learners of all ages and abilities. The use of SRL strategies in domain specific areas have proven effective in relation to increasing student ROC and achievement. Previously cited research supports student use of SRL strategies as influential mechanics in the acquisition and adaptation of knowledge, (e.g. Tzohar-Rozen & Kramarski, 2014), performance, (e.g., Fuchs et al., 2003), and ROC (e.g., Tzohar-Rozen & Kramarski, 2014). The researcher feels that it would be useful to extend the current study across a larger population for an extended period to see if the findings would yield different results. This is planned for a future study.

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APPENDIX A

Grade 1 and 3-Treatment Daily Task Script

Explicit Instruction Script

Step 1. Understand the Problem

Teacher to students:

T: Reads daily task problem aloud
T: Ask students to chorale read daily task aloud.
T: Reads: “Do I understand the problem?”
T: Asks students to chorale read question aloud and answer.

Step 2. Devise a plan to solve the problem

T: Reads: “Have I solved a problem like this before?”
T: Asks students to chorale read question aloud and answer.
T: Reads: “What model am I going to use?” -Picture? Number line? Bar model? Number bond?
T: Asks students to chorale read aloud and answer.

Step 3. Implement the Plan

Allow 30-45 seconds to work on problem. Stop students from working.

T: Reads: “Is my model working?”
T: Asks students to chorale read question and answer.

Scenario1-Plan IS working

T: YES-Continue until problem has been solved.

Scenario 2-Plan IS NOT working

T: No-Go to the list of models and circle a new one- begin working.
T: Ask: “Is my model working?”
T: Continue until problem has been solved

Step 4: Reflection

T: Reads: “Does the answer make sense?”
T: Ask students to chorale read question aloud and answer.
T: Reads: “Could I have solved it a different way?”
T: Ask student to chorale read and aloud and answer.

APPENDIX B

Grade 1-Treatment cognitively guided tasks-SAMPLE

<table>
<tr><td rowspan="6">Kaylie had 5 bunnies. 8 more bunnies hopped over to join them. How many bunnies does Kaylie have now?</td><td rowspan="3">Before</td><td>Do I understand the problem?</td><td>Y</td><td>N</td></tr>
<tr><td>Have I solved a problem like this before?</td><td>Y</td><td>N</td></tr>
<tr><td>How will I solve the problem?</td><td colspan="2">Picture
Number Line
Bar Model
Other
Number Bond</td></tr>
<tr><td>During</td><td>Is my model working?</td><td>Y</td><td>N</td></tr>
<tr><td rowspan="2">After</td><td>Does my answer make sense?</td><td>Y</td><td>N</td></tr>
<tr><td>Could I solve it another way?</td><td>Y</td><td>N</td></tr>
</table>

<table>
<tr><td rowspan="6">Tim had 5 toy cars. His friend gave him some more. Then he had 15 toy cars. How many toy cars did his friend give him?</td><td rowspan="3">Before</td><td>Do I understand the problem?</td><td>Y</td><td>N</td></tr>
<tr><td>Have I solved a problem like this before?</td><td>Y</td><td>N</td></tr>
<tr><td>How will I solve the problem?</td><td colspan="2">Picture
Number Line
Bar Model
Other
Number Bond</td></tr>
<tr><td>During</td><td>Is my model working?</td><td>Y</td><td>N</td></tr>
<tr><td rowspan="2">After</td><td>Does my answer make sense?</td><td>Y</td><td>N</td></tr>
<tr><td>Could I solve it another way?</td><td>Y</td><td>N</td></tr>
</table>

APPENDIX C

Grade 3-Treatment cognitively guided tasks Tasks-SAMPLE

Kaylie had 210 rocks in her collection. She added 174 rocks to her collection. How many rocks does Kaylie have now?	Before	Do I understand the problem?	Y	N
		Have I solved a problem like this before?	Y	N
		How will I solve the problem?	Picture Number Line Bar Model Other Number Bond	
	During	Is my model working?	Y	N
	After	Does my answer make sense?	Y	N
		Could I solve it another way?	Y	N

Tim had 397 Lego pieces. His friend gave him some more. Then he had 713 Lego pieces. How many Lego pieces did his friend give him?	Before	Do I understand the problem?	Y	N
		Have I solved a problem like this before?	Y	N
		How will I solve the problem?	Picture Number Line Bar Model Other Number Bond	
	During	Is my model working?	Y	N
	After	Does my answer make sense?	Y	N
		Could I solve it another way?	Y	N

APPENDIX D

Grade 1-Comparison cognitively guided tasks-SAMPLE

Kaylie had 5 bunnies. 8 more bunnies hopped over to join them. How many bunnies does Kaylie have now?	

Tim had 5 toy cars. His friend gave him some more. Then he had 15 toy cars. How many toy cars did his friend give him?	

APPENDIX E

Grade 3-Comparison cognitively guided tasks-SAMPLE

Kaylie had 210 rocks in her collection. She added 174 rocks to her collection. How many rocks does Kaylie have now?	

Tim had 397 Lego pieces. His friend gave him some more. Then he had 713 Lego pieces. How many Lego pieces did his friend give him?	

APPENDIX F

Grade 1-CGI Word Problem Assessment-Version A

1. Allison has 5 cards. She picked up 10 more cards. How many cards does she have now?
2. Jason has 9 apples. He picked some more apples. Now he has 19 apples. How many apples did he pick?
3. Maria had some pencils. She picked up 14 more pencils. Now she has 20 pencils. How many pencils did she have to start with?
4. Rachel has 38 straws. She used 10 of them. How many straws does she have now?
5. Juan has 17 stickers. He used some of them. He now has 9 stickers. How many stickers does Juan have left?
6. Isabel has some buttons. She used 13 of them. Now she has 7 buttons. How many buttons does she have to begin with?
7. Mr. Bill had some beads. He gave 15 to Cindy. He had 4 beads left. How many beads did Mr. Bill have to start with?
8. Mr. Myers had 6 white cookies and 10 pink cookies. How many cookies did Mr. Myers have altogether?
9. Jayden had 44 ribbons. 20 were pink and the rest were white. How many white ribbons did Jayden have?

10. Tom had 13 cats. Jen had 3 cats. How many more cats did Tom have than Jen?

11. Deb had 27 cards. Matt had 10 more cards than Deb. How many cards did Matt have?

12. Nino had 18 erasers. He had 5 more than Aaron. How many erasers did Aaron have?

APPENDIX G

Grade 3-CGI Word Problem Assessment-Version A

1. Allison has 426 cards. She picked up 319 more cards. How many cards does she have now?
2. Jason has 174 apples. He picked some more apples. Now he has 398 apples. How many apples did he pick?
1. Maria had some pencils. She picked up 114 more pencils. Now she has 124 pencils. How many pencils did she have to start with?
2. Rachel has 111 straws. She used 53 of them. How many straws does she have now?
3. Juan has 270 stickers. He used some of them. He now has 190 stickers. How many stickers did Juan use?
4. Isabel had some buttons. She used 313 of them. Now she has 8 buttons. How many buttons did she have to begin with?
5. Mr. Bill had some beads. He gave 349 to Cindy. Then, he had 70 beads left. How many beads did Mr. Bill have to start with?
6. Mr. Myers had 74 white cookies and 84 pink cookies. How many cookies did Mr. Myers have altogether?
7. Jayden had 567 ribbons. 41 were pink and the rest were white. How many white ribbons did Jayden have?
8. Thomas had 117 blocks. Kaydence had 134 blocks. How many more blocks did Kaydence have than Thomas?
9. Debbie had 695 pennies. Mathew had 105 more pennies than Debbie. How many pennies did Matthew have?

10. Nino had 188 erasers. He had 75 more than Aaron. How many erasers did Aaron have?

APPENDIX H

Jr-MAI-Version A

We are interested in what learners do when they solve word problems. Please read the following sentences and circle the answer that relates to you and the way you are when you are doing math problems. Please answer as honestly as possible.

1. I know when I understand something.	Nev er	Some times	Alw ays
2. I can make myself learn when I need to.	Nev er	Some times	Alw ays
3. I try to use ways of studying that have worked for me before.	Nev er	Some times	Alw ays
4. I know what the teacher expects me to learn.	Nev er	Some times	Alw ays
5. I learn best when I already know something about the topic.	Nev er	Some times	Alw ays
6. I draw pictures or diagrams to help me understand while learning.	Nev er	Some times	Alw ays
7. When I am done with my schoolwork, I ask myself if I learned what I wanted to learn.	Nev er	Some times	Alw ays
8. I think of several ways to solve a problem and then choose the best one.	Nev er	Some times	Alw ays
9. I think about what I need to learn before I start working.	Nev er	Some times	Alw ays
10. I ask myself how well I am doing while I am learning something new.	Nev er	Some times	Alw ays
11. I really pay attention to important information.	Nev er	Some times	Alw ays
12. I learn more when I am interested in the topic.	Nev er	Some times	Alw ays